

ESSAYS ON FLEXIBLE EXCHANGE RATES

By

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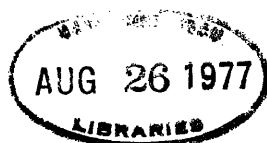


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"Flexible Exchange Rates in the Short Run," (with Rudiger Dornbusch), Brookings Papers on Economic Activity, 3: 1976.

"A Model of the Portuguese Economy," (with A. Abel, B. Belezza, J. Frankel and R. Hill), Economia (Lisbon), Vol. 1, No. 1 (January 1977).

"Contractionary Effects of Devaluation," (with Lance Taylor), Journal of International Economics, forthcoming.

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By

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Abstract

The behavior of economies with floating exchange rates is examined in three related essays. Essay I examines the relationship between prices and exchange rates during a number of episodes of flexible exchange rates, and finds considerable support for the hypothesis of purchasing power parity. Essay II is concerned with the efficiency of the market in forward exchange; it finds that the hypothesis of "rational expectations", while appearing plausible for some historical episodes, can be rejected for recent experience. Finally, Essay III examines the popular argument that economies under floating exchange rates are vulnerable to destabilizing speculation. It shows how this is possible in theoretical models; but an examination of an alleged example of destabilizing speculation, France during the 1920's, suggests that government policy, rather than any malfunctioning of markets, was responsible for the instability of the franc.

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ESSAY I

PURCHASING POWER PARITY AND EXCHANGE RATES:

ANOTHER LOOK AT THE EVIDENCE

Introduction

There is a perennial debate in international economics between those who regard the exchange rate as (nothing but) the relative price of two monies, and those who regard it as (also) the relative price of domestic and foreign goods. The proposition that relative goods prices are not affected by exchange rates -- or, equivalently, that exchange rate changes will be proportional to relative inflation -- is generally referred to as the doctrine of purchasing power parity.¹ While purchasing power parity is not a complete theory of exchange rates, any more than its alter ego, the law of one price, is a complete theory of world inflation under a fixed rate regime, PPP would have important implications for the analysis of flexible rates if true.

Few international economists would deny that purchasing power parity holds in some sufficiently long run. But most would probably be skeptical of any assertion that PPP holds in the short run. Inspection of data on prices and exchange rates suggests that relative inflation is not always reflected in exchange rate changes, on one hand, and that changes in exchange rates produce changes in relative prices, that is, are not fully reflected in differential inflation, on the other.² As a result, working

¹ Work on purchasing power parity is surveyed in Officer (1976).

² An analysis of this kind may be found in Dornbusch and Krugman (1976).

economists generally use PPP as a long-run theory while relying on a Keynesian theory, in which exchange rates affect relative prices, for short-run analysis.

The purpose of this paper is to cast a skeptical look at the received wisdom on exchange rates and prices. In essence, the argument is that problems arising from the fact that neither prices nor exchange rates can properly be regarded as exogenous could lead one to reject PPP in a world in which it was in fact valid. This is particularly likely to happen in a world of "dirty" or "managed" floating, in which the monetary authority's behavior is affected by the exchange rate.

To provide support for this skepticism, I examine some of the evidence on prices and exchange rates from the two major episodes of floating exchange rates in this century: the period of inconvertibility following the First World War, and the period following the breakdown of the Smithsonian Accord in 1973. I show that simple statistical tests lead one to reject PPP, but that this rejection can be explained by a simple model in which PPP is actually true. I then test purchasing power parity by methods which allow for the endogeneity of both prices and exchange rates, and come up with results more favorable to PPP.

The paper is in four sections. The first section carries out some simple tests of PPP, which produce unfavorable results for all countries except some of those experiencing high inflation. The second section develops a model of exchange rate determination, and shows how the simultaneity of the system can bias the tests of the first section. In the third section some tests designed to bypass these difficulties are carried

out, which appear to put PPP in a more favorable light. Some further evidence is presented, however, which casts renewed doubt on the adequacy of PPP as a short-run theory. Finally, in the fourth section, the evidence is summarized.

I. Simple Tests of Purchasing Power Parity

The hypothesis of purchasing power parity may be written as

$$(1) \quad S = AP/P^*$$

where S = exchange rate, domestic currency for foreign

A = arbitrary constant term

P = domestic price level, in domestic currency

P^* = foreign price level, in foreign currency

It is often convenient to state PPP as a proposition about the logarithms of variables. Let lower-case letters represent the logs of the variables just defined; then PPP implies

$$(2) \quad s = a + p - p^*$$

A natural test of PPP, which has been employed by Bilson (1976), Frenkel (1976), and Frankel (1977), is to regress the spot exchange rate on relative prices, that is, to estimate the equation

$$(3) \quad s = a + b(p - p^*)$$

We can then test PPP by testing the hypothesis $b = 1$.

In Table I I report estimates of (3), based on monthly data on wholesale prices and exchange rates, for seven floating exchange rates. The

Table I
TESTS OF PPP, ORDINARY LEAST SQUARES

<u>Exchange</u>	<u>Time Period</u>	<u>a</u>	<u>b</u>	<u>SEE</u>	<u>R²</u>	<u>D-W</u>
Mark/Dollar	Feb. 1920- Dec. 1923	-.382 (.030)	0.980 (.004)	0.171	0.999	0.677
Dollar/Pound Sterling	Feb. 1920- Dec. 1925	-.085 (.006)	0.812 (.040)	0.039	0.859	0.387
French Franc/ Dollar	Feb. 1920- Dec. 1926	-.026 (.015)	1.139 (.033)	0.080	0.935	0.324
Mark/Dollar	July 1973- Dec. 1976	.054 (.016)	-0.113 (.131)	0.051	0.018	0.522
Lira/Dollar	July 1973- Dec. 1976	.111 (.009)	1.429 (.092)	0.051	0.858	0.228
Swiss Franc/ Dollar	July 1973- Dec. 1976	.037 (.015)	0.659 (.099)	0.058	0.527	0.759
Pound Sterling /Dollar	July 1973- Dec. 1976	.042 (.011)	1.337 (.086)	0.052	0.859	0.336

Notes: These regressions are ordinary least squares estimates of the equation $s = a + b(p - p^*)$ where s is the log of the exchange rate, p and p^* the logs of domestic and foreign wholesale prices, respectively. Numbers in parentheses are standard errors.

All data is monthly; for the 1920's it is from International Abstract of Economic Statistics, for the 1970's from International Financial Statistics.

episodes chosen -- three from the 1920's, four from the 1970's -- cover a wide variety of experience. In the 1920's Germany experienced a hyperinflation, France a high but not catastrophic rate of inflation, while in Britain prices fell by more than 50 percent over the period. In the 1970's Britain and Italy had high inflation, Germany low inflation, and Switzerland nearly stable prices.

The results of the test are not encouraging for PPP. Of the seven estimates of b , one has the wrong sign, and only two, the estimates for the franc and mark in the 1920's, are particularly close to one. And the fact that the coefficient for hyperinflation Germany is close to one is in some ways deceptive. When prices grow by a factor of a hundred billion, even a small deviation of b from one can produce large changes in relative goods prices.

A formal test of the hypothesis $b = 1$ leads to rejection of the hypothesis for all seven exchange rates. The test is of doubtful value, however, since the Durbin-Watson statistics indicate substantial serial correlation of the errors. If we are willing to assume first-order serial correlation, the equations can be reestimated using Cochrane-Orcutt, and the hypothesis $b = 1$ tested with an asymptotic t -statistic. This is done in Table II.

The results in Table II do not give much comfort to the believer in PPP. It is true that there are now two exchange rates, the lira and the pound sterling in the 1970's, for which the hypothesis $b = 1$ cannot be rejected, but that is not exactly strong support for the theory. Several of the estimates of b change a great deal, suggesting that the serially

Table II
TESTS OF PPP, COCHRANE-ORCUTT

<u>Exchange Rate</u>	<u>Time Period</u>	<u>a</u>	<u>b</u>	<u>SEE</u>	<u>R²</u>	<u>ρ</u>
Mark/Dollar	Feb. 1920- Dec. 1923	-.398 (.062)	0.981 (.007)	.127	0.9996	0.641
Pound Sterling /Dollar	Feb. 1920- Dec. 1925	-.098 (.016)	0.719 (.091)	.023	0.951	0.794
French Franc/ Dollar	Feb. 1920- Dec. 1926	-.097 (.054)	1.291 (.093)	.044	0.981	0.880
Mark/Dollar	July 1973- Dec. 1976	.109 (.050)	0.328 (.373)	.034	0.552	0.762
Lira/Dollar	July 1973- Dec. 1976	.136 (.054)	1.101 (.210)	.023	0.970	0.921
Swiss Franc/ Dollar	July 1973- Dec. 1976	-.107 (.081)	-.096 (.130)	.036	0.819	0.930
Pound Sterling /Dollar	July 1973- Dec. 1976	.271 (.155)	.515 (.439)	.028	0.957	0.963

Notes: These are estimates of the equation $s = a + b(p - p^*)$, with the variables defined as in Table I, under the assumption of first-order serial correlation. The column labeled ρ gives estimates of the coefficient of serial correlation. Numbers in parentheses are asymptotic standard errors.

correlated errors are actually evidence of misspecification -- omitted variables which are correlated with relative prices.¹ And the estimated serial correlation is very high for some of the exchange rates, even bearing in mind that we are dealing with monthly data. This is further evidence that something is wrong with PPP, even for the lira, where the coefficient b is near one.

These simple tests, then, confirm the casual impression that exchange rate movements in the short run are not closely related to price changes. But careful consideration of the role of purchasing power parity in a model of the exchange rate shows that tests of this kind might lead us to reject PPP when it is, in fact, true.

II. Purchasing Power Parity in a Simple Model of the Exchange Rate

In this section I analyze some pitfalls in the testing of purchasing power parity. I develop a simple model of exchange rates which has three elements: a purchasing power parity equation, a price level equation, and a reaction function of the monetary authority. In this simple model an ordinary least squares estimate of the kind carried out in Section I will be biased, generally in such a way as to make prices seem to be less than fully reflected in the exchange rate.

It must be emphasized that the model developed in this section is not seriously advanced as a complete theory of exchange rates. The extreme simplicity and monetarist flavor of the model are not so much proposed as realistic aspects of the world as they are used as debating points. By showing

¹ The use of the change in estimated parameters when generalized least squares is applied to test for misspecification has been proposed by Hausman (1977).

that a monetarist world can appear to observers to be anything but, the model encourages more caution in the interpretation of evidence.

Let us suppose, then, that the exchange rate and price level are determined simultaneously as part of a three equation system. The first is the equation of purchasing power parity,

$$(4) \quad s = a + p - p^* + u$$

where s , p , p^* have the definitions given above and u is a random term. The economic interpretation of changes in u is that they are changes in the price of domestic relative to foreign goods on world markets.

The next equation is the demand for money, which may also be regarded as an equation for the price level,

$$(5) \quad m = p + y + v$$

where m is the log of the money supply, y the log of real income, and v another random term.¹

To these equations we add the supply of money. As we will see in a moment, the possibility that the behavior of the monetary authority may depend in part on the exchange rate has important econometric implications. We can formalize this by an equation of the form

$$(6) \quad m = \bar{m} - \theta s + w$$

¹ I omit any interest rate effect for simplicity. This also prevents the variation of the exchange rate from having any speculative component.

where w is still another random term. The general idea here is that the monetary authority attempts to dampen exchange rate fluctuations by reducing the money supply when the currency depreciates and increasing it when the currency appreciates.

Finally, let us close the system by assuming p^* and y fixed. The first is the presumably harmless "small-country" assumption, the second a drastic simplification which is justified only by the fact that we are attempting to illustrate a point rather than be fully realistic.¹

Now there are two ways in which researchers generally look at purchasing power parity. One is to ask whether differential inflation is reflected in exchange rate changes. This is more or less equivalent to estimating the equation $s = a + b(p - p^*)$ and asking whether b equals one. The other way of looking at PPP is to ask whether exchange rate changes affect relative goods prices. One way of doing this would be to estimate the equation $(s - p + p^*) = c + ds$, where the expression $(s - p + p^*)$ is what is sometimes referred to as the real exchange rate.

Suppose a researcher were to estimate these two equations, and the model we have just developed were a true representation of the world. What would he find? The answer obviously depends on the distribution of the shocks u , v , and w . In the general case where u , v , and w are correlated, anything can happen. If we assume the shocks are uncorrelated with variances σ_u^2 , σ_v^2 , σ_w^2 , the probability limits of the coefficients in the two test

¹ Obviously, sticky prices or wages would make y endogenous. Allowing for them would, unfortunately, complicate the model so much as to make it completely unmanageable.

equations become:¹

$$\text{plim } \hat{b} = \frac{-\theta\sigma_u^2 + \sigma_v^2 + \sigma_w^2}{\theta^2\sigma_u^2 + \sigma_v^2 + \sigma_w^2} < 1$$

$$\text{plim } \hat{d} = \frac{(1 + \theta)\sigma_u^2}{\sigma_u^2 + \sigma_v^2 + \sigma_w^2} > 0$$

These are suggestive results. Examining the expressions for \hat{b} and \hat{d} yields several insights about the kinds of pitfalls one is likely to encounter in empirical work on prices and exchange rates:

(i) As long as the monetary authority makes some effort to stabilize the exchange rate ($\theta > 0$) and there are "real" as well as "nominal" shocks ($\sigma_u^2 > 0$), one will observe a failure of inflation to be fully reflected in the exchange rate, and exchange rate changes will seem to have an effect on relative goods prices.

(ii) If, however, nominal disturbances are very large relative to real disturbances (σ_v^2 and σ_w^2 large relative to σ_u^2), the estimated coefficients will be close to their true values. This is of course no more than a special case of Samuelson's (1964) observation that we should only expect PPP to hold when disturbances are purely monetary in character.

On reflection these observations may be obvious, but they can easily be overlooked. It is important that empirical testing of PPP take account of the statistical problems caused by simultaneity. In the next section I

¹ In the general case it is not possible to derive small sample results for these estimates. If we are willing to assume normality of u , w , and v , however, the probability limits are also the expected values of b and d in small samples.

attempt to test purchasing power parity in ways that avoid the difficulties analyzed in this section.

III. Revised Tests of PPP

The upshot of the argument in the last section was that simple regressions of exchange rates on prices or vice versa are liable to give rise to coefficients which differ from one because neither the exchange rate nor the price level can properly be regarded as exogenous. There are two ways of getting around this problem. One is to restrict one's empirical testing to cases in which monetary shocks predominate over everything else. Thus Frenkel (1976) is justified in using ordinary least squares to analyze the German hyperinflation. For cases where monetary events are not so extreme, we can attempt to deal with simultaneity by using an instrumental variable technique.

The usual problem in applying instrumental variables is the difficulty in finding suitable instruments. For testing PPP, however, there is a relatively easy way out. For all of the exchange rates covered in this paper, prices in the country rose either markedly faster or markedly more slowly than in the U.S. during the period examined. Thus a time trend, which we can reasonably hope is uncorrelated with the errors in the PPP equation, forms a fairly good instrument for relative prices.

Table III reports the results of estimating the equation $s = a + b(p - p^*)$ by instrumental variables for the six non-hyperinflation episodes. These results are not too different from the ordinary least squares results reported in Table I. As before, Germany in the 1970's shows a perverse

Table III
TESTS OF PPP, INSTRUMENTAL ESTIMATES

<u>Exchange Rate</u>	<u>Time Period</u>	<u>a</u>	<u>b</u>	<u>SEE</u>	<u>R²</u>	<u>D-W</u>
Pound Sterling /Dollar	Feb. 1920- Dec. 1925	-.074 (.067)	0.946 (.054)	0.042	0.835	0.352
French Franc/ Dollar	Feb. 1920- Dec. 1926	-.002 (.016)	1.070 (.037)	0.082	0.932	0.318
Mark/Dollar	July 1973- Dec. 1976	.051 (.017)	-.145 (.142)	0.051	0.017	0.523
Lira/Dollar	July 1973- Dec. 1976	.100 (.010)	1.699 (.125)	0.056	0.827	0.215
Swiss Franc/ Dollar	July 1973- Dec. 1976	.049 (.016)	0.760 (.107)	0.058	0.514	0.840
Pound Sterling /Dollar	July 1973- Dec. 1976	.038 (.011)	1.378 (.089)	0.052	0.858	0.337

Notes: These are all estimates of the equation $s = a + b(p - p^*)$, where the variables are as defined in Table I. The estimates are by instrumental variables, using a constant and a time trend as instruments. Figures in parentheses are asymptotic standard errors.

relationship, while the other estimates of b are distributed around one. Some are closer, some further; two estimates, for the pound and the franc in the 1920's, are now quite close to one and the hypothesis $b = 1$ cannot be rejected for them. As before, however, the serial correlation of the errors, indicated by the low Durbin-Watson statistics, invalidates the tests.

When we correct for serial correlation, in Table IV, the instrumental variable approach makes more of a difference. Where in Section I we found that taking serial correlation into account caused several coefficients to change drastically, in this case the coefficients do not change much. What do change are estimated standard errors: taking serial correlation into account, it is no longer possible to reject the hypothesis $b = 1$ at the 95 percent level for any of the episodes. It appears that the perverse result for the mark may at least in part reflect the fact that, since German and U.S. inflation have not been too different, there is very little power in the test. We should also note that a reassuring result of applying instrumental variables is that in every case the estimated serial correlation of the errors goes down (we will have more to say about serial correlation below).

While not overwhelming, these results are more favorable to PPP than the results of the first section. They indicate that the diehard believer in PPP can make a case that the apparent failures of PPP in the short run actually represent the interaction of real shocks and endogenous monetary policy. Is there any way to refute this argument? There are several ways in which we might try to evaluate PPP as a theory. We can ask how much it

Table IV
TESTS OF PPP, INSTRUMENTAL VARIABLES CORRECTED
FOR FIRST-ORDER SERIAL CORRELATION

<u>Exchange Rate</u>	<u>Time Period</u>	<u>a</u>	<u>b</u>	<u>SEE</u>	<u>R²</u>	<u>ρ</u>
Pound Sterling /Dollar	Feb. 1920- Dec. 1925	-.084 (.017)	0.856 (.125)	.023	0.949	0.781
French Franc/ Dollar	Feb. 1920- Dec. 1926	.002 (.057)	1.053 (.122)	.046	0.979	0.839
Mark/Dollar	July 1973- Dec. 1976	.089 (.055)	0.168 (.427)	.034	0.550	0.740
Lira/Dollar	July 1973- Dec. 1976	.070 (.066)	1.651 (.460)	.025	0.965	0.896
Swiss Franc/ Dollar	July 1973- Dec. 1976	.059 (.032)	0.817 (.208)	.049	0.660	0.554
Pound Sterling /Dollar	July 1973- Dec. 1976	.038 (.044)	1.405 (.268)	.029	0.954	0.833

Notes: These are estimates of the equation $s = a + b(p - p^*)$ by instrumental variables under the assumption that errors have first-order serial correlation. A time trend and a constant were used as instruments. Numbers in parentheses are asymptotic standard errors.

explains; we can ask how large the deviations from PPP are in some absolute sense; and we can ask whether the deviations from PPP are in some sense systematic, i.e., whether there is evidence that a simple PPP explanation of the exchange rate omits important variables.

Table V presents some evidence bearing on these questions. One way of looking at PPP is as an assertion that the "real exchange rate" $s - p + p^*$ ought to remain relatively constant even if prices and the exchange rate are changing. In the first column the variance of the real exchange rate is compared with the variance of the exchange rate itself. In every case except that of modern Germany, the real exchange rate is in fact substantially more stable than the unadjusted rate. Not surprisingly, the difference is most marked for the exchange rates where the difference in inflation rates was largest.

The second column shows the standard deviation of the real exchange rate around its mean value, both measured in logs. Since the variables are in logs, these numbers can be interpreted as percentages. On this criterion, purchasing power parity does not look quite so good, since the variations in relative prices seem fairly considerable in absolute terms. For purposes of comparison, one might recall that such international monetary traumas as the return to gold in 1925, the devaluation of the pound sterling in 1967, and the effective devaluation of the dollar in 1971-73 involved exchange rate changes of only 10 to 20 percent.

Perhaps as important as the absolute size of the deviations from PPP is their distribution: they are largest for Germany, the country with the most unstable monetary events. The simple model of Section II would predict

Table V
SUMMARY STATISTICS ON PPP

<u>Exchange Rate</u>	<u>Time Period</u>	<u>Variance Ratio</u>	<u>Standard Deviation</u>	<u>Serial Correlation</u>
Mark/Dollar	Feb. 1920-Dec. 1923	0.0005	0.208	0.765
Pound Sterling /Dollar	Feb. 1920-Dec. 1925	0.187	0.044	0.828
French Franc/ Dollar	Feb. 1920-Dec. 1926	0.079	0.088	0.851
Mark/Dollar	July 1973-Dec. 1976	2.761	0.084	0.854
Lira/Dollar	July 1973-Dec. 1976	0.228	0.063	0.935
Swiss Franc/ Dollar	July 1973-Dec. 1976	0.614	0.065	0.538
Pound Sterling /Dollar	July 1973-Dec. 1976	0.196	0.060	0.897

Notes: The numbers have the following interpretations. The variance ratio is the ratio of the variance of the log of the real exchange rate, $s - p + p^*$, to the variance of the log of the exchange rate proper. The standard deviation is the standard deviation of the log of the real exchange rate. Serial correlation is the estimated first order serial correlation of the deviation of $s - p + p^*$ from its mean value.

no relationship between the two, since variations in the real exchange rate would be produced by shocks independent of monetary events. This cross-sectional evidence may be a sounder basis for questioning PPP than the time series evidence usually used.

Finally, the last column shows the estimated serial correlation of deviations of the real exchange rate from its mean. The serial correlation is substantial in all cases. It is true that, bearing in mind that this is monthly data, the degree of serial correlation is not unusual for an economic model; but this may be more of a comment on the success of economic models in general than on the validity of PPP. In any case, the serial correlation might be taken as evidence of omitted variables determining the exchange rate.

There is some evidence, then, that there is more to exchange rates than PPP. This evidence is that the deviations of exchange rates from PPP are large, fairly persistent, and seem to be larger in countries with unstable monetary policies.

IV. Conclusions

This paper has reviewed some of the evidence on prices and exchange rates, with the intention of testing the validity of the popular theory of purchasing power parity. It reached the following conclusions:

(i) Simple tests reject the hypothesis that exchange rate changes are proportional to relative inflation for all cases studied.

(ii) A theoretical analysis suggests, however, that simple tests of PPP can be misled by problems of simultaneity.

(iii) When methods designed to avoid these problems are applied, the results are more favorable to PPP.

(iv) Finally, however, further examination of the evidence does turn up some more subtle evidence that there is more to exchange rates than PPP.

The moral of this paper is not, then, that purchasing power parity is always and continuously true. Rather, it is that one must be cautious in determining the extent of and the reasons for failure of PPP to hold, for the world has laid statistical traps for the unwary.

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ESSAY II

THE EFFICIENCY OF THE FORWARD EXCHANGE MARKET:
EVIDENCE FROM THE TWENTIES AND THE SEVENTIES

Introduction

One of the central questions about the functioning of a flexible exchange rate regime is the role of speculation. Both during the interwar period and more recently it has been argued by some that, when governments do not intervene to stabilize them, exchange markets are subject to large scale speculative runs which can have disruptive effects on the rest of the economy. Fear of destabilizing speculation is a major reason why most of the world's countries continue to peg their currencies, and why most countries with floating currencies continue to intervene to smooth out fluctuations.¹

There is an equally venerable argument, however, which denies that speculation can have any independent disruptive effect on an economy which is otherwise stable. This point of view was perhaps best expressed by Keynes (1924), who wrote that "the successful speculator makes his profit by anticipating, not by modifying, existing economic tendencies." In recent years this argument has been formalized in models in which expectations are assumed to be "rational" in the sense of Muth (1961). This concept of rationality holds that participants in a market use all available information in forming their expectations, and that as a consequence the expectations of

¹ The argument that speculation can have destabilizing effects was made effectively by Nurkse (1944). More recently, a similar doctrine has become popular under the name of the "vicious and virtuous circle of prices and exchange rates." The best-known exposition of this doctrine is the speech of Bernard Clappier at the IMF Meeting in Manila, 1975.

the market are the same as the prediction of the model. In models which assume rational expectations the economy is never destabilized by speculation if it would otherwise have been stable.¹

The purpose of this paper is to present some evidence on the rationality of expectations under flexible exchange rates. Specifically, I test the market in forward exchange for the presence of unexploited information. Previous work on this subject has produced conflicting results. Aliber (1975), Dooley and Schafer (1976), and Frankel (1977), examining the post-1973 experience, have found evidence of unexploited information. On the other hand, Frenkel (1976, 1977), examining data from the 1920's, has found substantial support for the hypothesis of rational expectations. One of the major conclusions of this paper is that the difference in results is in large part due to the choice of different episodes to study; the evidence indicates that this is a case where "things don't work like they used to."

In this paper I examine the behavior of six forward exchange rates: the mark/pound, French franc/pound, and dollar/pound rates in the 1920's; the mark/dollar, pound/dollar, and lira/dollar rates in the 1970's. The paper is in four sections. Section I examines the hypothesis of rational expectations, and develops a standard set of tests. In Section II these tests are applied in turn to each of the five non-hyperinflation exchange rates. Section III looks in some detail at the mark exchange rate in the 1920's, a case which presents special conceptual and statistical difficulties because of the extreme rate of depreciation. Finally, Section IV summarizes the results of previous sections.

¹ There are many exchange rate models assuming rational expectations. A representative model is that of Mussa (1976); for further discussion and references, see the survey by Isard (1977).

I. Testing Rationality of Forward Markets

Testing rationality of markets has become an important growth industry in the economics profession. In this section I examine what behavior the forward market would exhibit if it were "rational," and develop a set of approximate tests. The limitations of the tests are also given a preliminary discussion.

If we ignore the existence of margin requirements, the forward exchange market is purely a market in gambles, requiring no current commitment of funds. Dealers in forward exchange agree to exchange currencies at a future date at a predetermined rate of exchange, and then make capital losses or gains depending on the actual rate of exchange when the contract comes due. An examination of these losses or gains suggests a simple criterion for rationality. Suppose that at time $t-1$ an investor buys marks forward (and sells dollars forward), with the contract due at time t . He is then assured, for every dollar's worth of contract, of receiving FR_{t-1} marks at time t , where FR_{t-1} is the forward exchange rate when the contract is signed. On the other hand, he must give up SR_t marks to buy the dollar to honor his end of the contract, where SR_t is the spot rate when the contract comes due. His profit is then $FR_{t-1} - SR_t$. A natural assumption would be that in an efficient market expected profits will be competed away, so that we will find $FR_{t-1} = E[SR_t / I_{t-1}]$, where the expectation of SR is taken conditional on all information available to the market at time $t-1$.

Even assuming risk-neutrality, however, this cannot be quite right. For if we had measured the profits in dollars instead of marks, the criterion

would instead have come out $(1/FR_{t-1}) = E[(1/SR_t)]$. Since $1/SR$ is a convex function, both criteria cannot be satisfied simultaneously. This is a well-known paradox;¹ it is related to some of the paradoxes which arise in indexation (see, for example, Fischer (1975)). There are several possible solutions:

(i) We can make a full analysis in terms of the utility functions of speculators and the resulting market demand curves. This has been done by Kouri (1976); unfortunately, it does not yield any easily testable propositions.

(ii) If all speculators can be presumed to agree on some common price index, we can look at the expected real value of a contract. This approach will be used in the discussion of hyperinflation in Section III, below.

(iii) Finally, a solution which implicitly lies behind most empirical testing is that if the uncertainty about the exchange rate is small, both criteria can be approximately fulfilled. Numerical examples confirm that, for the size of uncertainty found other than in very high inflations, the difference between $E[1/SR]$ and $1/E[SR]$ will not be very large.²

When uncertainty is small, then, testing whether the forward rate is the expected future spot rate is an approximate test for rationality. Rather than choose to measure the exchange rate in one currency or the other, a popular compromise is to use logarithms, so that the test criterion

¹ The issue is discussed in papers by Roper, McCulloch, and Siegel (all 1975). Those authors agreed that the problem is empirically unimportant, which is correct for normal circumstances but, as shown later, not under conditions of very high inflation.

⁴ For example, consider an exchange rate which one month from now has an equal probability of being 1.05 and 0.95. This would ordinarily be considered a high degree of uncertainty; but the difference between $1/E[SR]$ and $E[1/SR]$ is only 0.25 percent.

becomes

$$(1) \quad E[S_t \mid I_{t-1}] - F_{t-1} = 0$$

where

$$S_t = \log \text{ of } SR_t$$

$$F_t = \log \text{ of } FR_t$$

This criterion will also be approximately correct if uncertainty is small.

How can we test to see whether (1) is true? In principle we should examine all information that was available to the market when a forward contract was signed, and ask whether this information in combination with the forward rate yields a better prediction of S than the forward rate alone. In practice we will usually be satisfied with asking whether some small set of information, generally drawn from the history of exchange rates, allows us to add anything to the forward rate.

In the next section I will apply four regression-based tests of the rationality of the forward market:

(i) There should not be any persistent bias in prediction errors, because otherwise profits could be earned by always selling one currency forward. This can be tested by estimating the equation

$$(2) \quad S_t - F_{t-1} = a$$

and testing the hypothesis $a = 0$.

(ii) As long as we examine contracts which do not overlap, there must not be any serial correlation of errors in prediction.¹ This can be tested

¹ Frankel (1977) has shown that prediction errors from overlapping contracts will follow a moving average process when expectations are rational.

by estimating the nonlinear equation

$$(3) \quad S_t - F_t = a(1 - \rho) + \rho(S_{t-1} - F_{t-2})$$

and testing the joint hypothesis $a = \rho = 0$.

(iii) The forward rate itself must not contain any information about prediction errors. This can be tested by estimating

$$S_t - F_{t-1} = a + b'F_{t-1}$$

and testing $a = b' = 0$. I will actually run the equivalent regression

$$(4) \quad S_t = a + bF_{t-1}$$

under the assumption of first-order serial correlation, and test the three way hypothesis $a = \rho = 0$, $b = 1$.

(iv) Finally, past exchange rates must not add any information. I will test this by running

$$(5) \quad S_t = a + bF_{t-1} + cS_{t-2}$$

under the assumption of first-order serial correlation, and test the hypothesis $a = c = \rho = 0$, $b = 1$.

It is important to note that these are all necessary conditions for rationality, and that none of them are sufficient. This has two implications. First, it is never possible to prove rationality, because there may always be some variable known to the market but not considered by the researcher which would have allowed better predictions. Second, the market must pass all the tests; a "best two out of three" condition is not sufficient.

II. Empirical Evidence: Low and Moderate Inflations

In the last section I developed a set of tests for the rationality of the forward market. These tests are valid approximations when the dispersion of the exchange rate around its expected value is not too large. This will be the case for situations in which the difference in inflation between two countries is not more than a few percent per month. In this section I test rationality for five floating exchange rates which fit this description. The regression results are reported in Tables I - V, and the statistical tests based on the regressions are given in Table VI.

In each of Tables I - V, four regressions are reported, corresponding to equations (2) to (5) in Section I. The two episodes from the twenties are based on data in Einzig (1937); the other three on exchange rate data from the Harris Bank Weekly Review (Chicago). In all cases, weekly averages of one-month forward rates were used, with weeks chosen at one-month intervals so the contracts did not overlap.

The test statistics in Table VI consist of one simple t-statistic and three likelihood ratio tests. These latter were constructed by comparing the estimated sum of squared residuals from each equation, which we can call SSR, with the sum of squared prediction errors $(S_t - F_{t-1})^2 = SSR^*$. Under the hypothesis of rational expectations the ratio $n \cdot (SSR^* - SSR)/SSR$ is distributed as $\chi^2(K)$ where n is the number of observations and K the number of restrictions tested.¹

The episodes covered are the following:

¹ This test is derived in Theil (1971).

The French Franc, 1922-1926: Over the period 1922-26 the franc depreciated by roughly 150 percent against the pound sterling, with much of the depreciation taking place in two dramatic speculative attacks in 1923-24 and 1926. In late 1926 there was a de facto stabilization which passed imperceptibly into de jure stabilization in 1928. I have argued elsewhere (Krugman (1977)) that the monetary history of France during the period can be understood in terms of the pressure on the government to reduce the real value of its World War I debts by inflation, and the efforts of the market to anticipate that inflation. The regressions in Table I and the tests in Table VI indicate that the market was fairly successful in doing so; we cannot reject the hypothesis of rational expectations.

The Pound Sterling, 1922-1925: The U.K. in the 1920's is one of the rare cases of a country pursuing a systematic policy of deflation. Tight credit was applied to gradually appreciate the pound to its pre-war parity. As in the case of the franc, the forward exchange market was apparently quite successful at second-guessing this policy; the hypothesis of rational expectations cannot be rejected.

The Deutsche Mark, 1973-1977: After the initial realignments of the rate in early 1973, there has been no obvious reason why the dollar-mark exchange rate should exhibit a secular trend; inflation in the two countries has been comparable. The exchange rate has gone through a series of fluctuations which in retrospect appear to have been cycles around a roughly constant central tendency, but which the market at the time took as permanent changes. This misjudgment is reflected in the coefficient on F_{t-1} in III.3, and in the rejection of rational expectations in Table VI.

Table I

TESTS OF RATIONAL EXPECTATIONS:

Franc/Pound Exchange Rate, Jan. 1922 - Dec. 1926

Equation	Dependent Variable	Constant	Coefficient on F_{t-1}	Coefficient on S_{t-2}	$\hat{\rho}$	SEE	R^2	D-W
I.1	$S_t - F_{t-1}$	0.0101 (.0104)	--	--	--	.0805	--	1.8426
I.2	$S_t - F_{t-1}$	0.0101 (.0111)	--	--	.0655	.0803	--	--
I.3	S_t	0.2470 (.1384)	.9471 (.0308)	--	.0856	.0790	.9513	
I.4	S_t	0.2487 (.1420)	.9612 (.1076)	-.0146 (.1102)	.0748	.0797	.9513	

Table II

TESTS OF RATIONAL EXPECTATIONS:

Dollar/Pound Exchange Rate, Jan. 1922 - Dec. 1925

Equation	Dependent Variable	Constant	Coefficient on F_{t-1}	Coefficient on S_{t-2}	$\hat{\rho}$	SEE	R^2	D-W
II.1	$S_t - F_{t-1}$	.0020 (.0021)	--	--	--	.0147	--	1.7769
II.2	$S_t - F_{t-1}$	.0019 (.0024)	--	--	.1103 (.1435)	.0146	--	--
II.3	S_t	.1342 (.0842)	.9126 (.0555)	--	.1223 (.1433)	.0144	.8881	--
II.4	S_t	.1259 (.0876)	.8950 (.1093)	.0231 (.1117)	.1131 (.1434)	.0146	.8881	--

Table III

TESTS OF RATIONAL EXPECTATIONS:

Mark/Dollar Exchange Rate, June 1973 - Feb. 1977

<u>Equation</u>	<u>Dependent Variable</u>	<u>Constant</u>	<u>Coefficient on F_{t-1}</u>	<u>Coefficient on S_{t-2}</u>	<u>$\hat{\rho}$</u>	<u>SEE</u>	<u>R^2</u>	<u>D-W</u>
III.1	$S_t - F_{t-1}$	-.0007 (.0041)	--	--	--	.0277	--	1.3400
III.2	$S_t - F_{t-1}$	-.0004 (.0053)	--	--	.2551	.0266	--	--
III.3	S_t	-.4274 (.1160)	.5360 (.1256)	--	.5489	.0246	.7161	--
III.4	S_t	-.2590 (.0772)	1.2105 (.1400)	-.4892 (.1441)	-.0280	.0242	.7350	--

Table IV

TESTS OF RATIONAL EXPECTATIONS:

Lira/Dollar Exchange Rate

<u>Equation</u>	<u>Dependent Variable</u>	<u>Constant</u>	<u>Coefficient on F_{t-1}</u>	<u>Coefficient on S_{t-2}</u>	<u>$\hat{\rho}$</u>	<u>SEE</u>	<u>R^2</u>	<u>D-W</u>
IV.1	$S_t - F_{t-1}$	.0018 (.0051)	--	--	--	.0341	--	1.7697
IV.2	$S_t - F_{t-1}$	.0012 (.0056)	--	--	.1050 (.1482)	.0339	--	--
IV.3	S_t	-.1285 (.0791)	.9334 (.0405)	--	.1258	.0333	.9418	--
IV.4	S_t	-.2207 (.1454)	.4378 (.1357)	.4543 (.1448)	.5442	.0317	.9464	--

Table V
TESTS OF RATIONAL EXPECTATIONS
Pound/Dollar Exchange Rate

<u>Equation</u>	<u>Dependent Variable</u>	<u>Constant</u>	<u>Coefficient on F_{t-1}</u>	<u>Coefficient on S_{t-2}</u>	<u>$\hat{\rho}$</u>	<u>SEE</u>	<u>R^2</u>	<u>D-W</u>
V.1	$S_t - F_{t-1}$	-.0030 (.0034)	--	--	--	.0027	--	1.1545
V.2	$S_t - F_{t-1}$	-.0022 (.0053)	--	--	.4213	.0205	--	--
V.3	S_t	.0239 (.0315)	.9652 (.0415)	--	.4521	.0206	.9761	--
V.4	S_t	.0236 (.0313)	1.0550 (.1615)	-.0880 (.1666)	.3977	.0211	.9756	--

Table VI
TEST STATISTICS

Proposition Tested	Test Statistic	95 Percent Level	Estimated Value For				
			Franc/ Pound 1922-26	Dollar/ Pound 1922-25	Mark/ Dollar 1973-77	Lira/ Dollar 1973-77	Pound/ Dollar 1973-77
$a = 0$	t	1.96	0.970	0.95	-0.18	0.23	-0.88
$a = \rho = 0$	$\chi^2(2)$	5.99	1.22	1.69	3.60	0.50	10.57
$a=\rho, b=1$	$\chi^2(3)$	7.81	4.31	4.34	13.13	3.33	11.66
$a=C=\rho=0, b=1$	$\chi^2(4)$	9.49	4.32	4.38	17.54	9.16	11.60

The Lira, 1973-1977: The Italian experience in the 1970's is in some respects reminiscent of France in the 1920's. Italy's indexed wage system makes the domestic inflation rate highly sensitive to the exchange rate. The exchange rate in turn is sensitive to the rate of monetary growth, which has for much of the period been tied to the financial needs of the public sector. As in the case of France, the market has been fairly successful in predicting these shifts, although the test in IV.4 comes close to rejecting rational expectations.

The Pound Sterling: Recent British economic history with the various phases of the social contract interacting with fiscal and monetary policy, and external shocks is too complicated to summarize here. It has also apparently been too much for the market. Prediction errors are strongly serially correlated, and this leads to rejection of rational expectations in Table VI.

Of the five exchange rates considered, then, we are unable to reject rational expectations for three -- although the lira is near the edge -- but are clearly able to reject it for the remaining two. Since the hypothesis of rational expectations is attractive and has proved productive in economic modeling, however, we are naturally inclined to ask whether there is any way to save it in these cases. There would appear to be three main lines of defense: risk aversion, low probability events, and learning. Let us consider each of these in turn.

(1) Risk aversion: The tests of rationality developed in Section I made the obviously untrue assumption of risk-neutrality; the assumption cannot be literally true, for if it were, there wouldn't be any need for a forward market. But the implications of risk aversion are unclear. Both

buyers and sellers of a forward currency are taking gambles, so the sign of a risk premium is indeterminate. We might relax the tests by allowing a constant risk premium, i.e., allowing the constant to differ from zero. But the rationality of the mark and pound markets in the 1970's is still rejected.

(ii) Low probability events: One well-known difficulty in testing the efficiency of markets is that market participants may have been concerned with the possibility of some unlikely but drastic event which did not, in the event, actually occur. The familiar example is the persistent discount on the Mexican peso, which was finally justified by the devaluation in 1976. In this kind of situation one may be led to reject rational expectations even when it is valid. From an econometric point of view, what this problem does is to make tests of the kind carried out in this paper valid only for very large samples; samples of 30-60 months may be quite inadequate.

There doesn't seem to be any rigorous way of dealing with this problem. The best we can do is ask for each case whether there was a low-probability, drastic event that the market can plausibly have been concerned about. In contrast to the case of Germany in the 1920's, considered below, where the possibility of stabilization can plausibly be asserted to have influenced behavior, there are no obvious candidates for Germany and Britain in the 1970's. Also, it is hard to see why the problem should be greater for those currencies than the others considered.

(iii) Learning: As Lucas (1976) has emphasized, rational expectations is an equilibrium concept which applies only when the market has had time to become accustomed to the economic environment. In the period following

a structural change, such as a transition from fixed to floating exchange rates, we might be able to reject the rationality of the forward market without there having been any unexploited profit opportunities given the information available to market participants. A suggestive piece of evidence is that rational expectations looks best for the cases in which monetary policy was dominated by a single consideration: the return to gold in 1920's Britain, revenue needs in 1920's France and, to a lesser extent, 1970's Italy.

While there may not have been any unexploited profits, however, this is not the same as saying that we are free to apply rational expectations models of the conventional kind. Little is known about the behavior of markets engaged in a learning process, but there is no reason why they should behave much like models of markets in which participants are assumed to know the structure of the economy.¹ And there is not even any assurance that the process will converge.

To summarize: while the rational expectations hypothesis fares very well for 1920's data and reasonably well for the lira in the 1970's, for the other recent episodes it can be rejected. The most attractive explanation of this rejection is that the markets are still engaged in a learning process; but this leaves unclear how we should model these markets.

¹ Some of the problems of interpreting rational expectations when markets are learning are discussed in Schiller (1975).

III. A Special Case: The Forward Market in Hyperinflation

The tests of rationality developed in Section I were approximate tests, where the approximation depends on the uncertainty about the spot exchange rate not being too large. There have been a number of attempts, however, to apply rational expectations to hyperinflations, in which the uncertainty about next month's exchange rate can be very large indeed.¹ This presents special problems. In this section I illustrate these problems by a consideration of the German hyperinflation 1921-1923.

We can begin by applying the same set of tests to hyperinflation. Germany as were applied to the other countries studied. The results are reported in Table VII. They are very unfavorable to the rational expectations hypothesis. There was a large bias, with the forward market apparently persistently underestimating depreciation. Prediction errors were highly serially correlated, and correlated with the forward rate as well. All tests indicate rejection of rational expectations.²

It should be noted that these results are in conflict with the conclusions reached by Frenkel (1976). Frenkel carried out a test similar to that reported as VII.3, an ordinary least squares regression of the log of the forward rate. Although the coefficient on the forward rate was, as here, significantly greater than one, Frenkel attributed this to transaction costs and "normal backwardation." Emphasizing that the residuals were not serially correlated, he took his results as favorable evidence for the rational expectations hypothesis. The results here indicate that he misinterpreted

¹ Rational expectations models of hyperinflation include Sargent and Wallace (1975) and Frenkel (1976).

² The four test statistics, corresponding to those in Table VI, were 3.02, 19.40, 40.18, and 41.06.

Table VII

TESTS OF RATIONAL EXPECTATIONS:

Mark/Pound Exchange Rate, Feb. 1921 - Sept. 1923

<u>Equation</u>	<u>Dependent Variable</u>	<u>Constant</u>	<u>Coefficient on F_{t-1}</u>	<u>Coefficient on S_{t-2}</u>	<u>$\hat{\rho}$</u>	<u>SEE</u>	<u>R^2</u>	<u>D-W</u>
VII.1	$S_t - F_{t-1}$	.3979 (.1317)	--	--	--	.7451	--	0.8834
VII.2	$S_t - F_{t-1}$	.6075 (.3372)	--	--	.6510	.6688	--	--
VII.3	S_t	-.9289 (.3139)	1.1537 (.0340)	--	.0637	.5737	.9771	--
VII.4	S_t	-1.2365 (.4762)	0.9737 (.1986)	.2263 (.2321)	.2533	.5903	.9767	--

the evidence. The bias in the forward rate was 40 percent per month, far too much for transactions costs and "normal backwardation" to explain.¹

But in any case tests on the logarithms of forward and spot rates can only be valid if uncertainty about the spot rate is small. As the standard errors of the equations reported in Table VII show, this was not the case in hyperinflation Germany. We need to develop a test that is valid whatever the degree of uncertainty.

It was suggested in Section I that an appropriate test might be to look at the expected real profit on a contract. Let P_t be the (uncertain) price level in Germany when a forward contract comes due. Recalling the definition of expected mark profits from Section I, the expected real profit on a contract would be

$E[SR_t/P_t] - E[FR_{t-1}/P_t]$, so that the condition for zero expected profit is

$$(6) \quad E[SR_t/P_t] = E[FR_{t-1}/P_t],$$

with both expectations taken conditional on information available at time $t-1$.

There will be a corresponding condition if profits are taken in dollars:

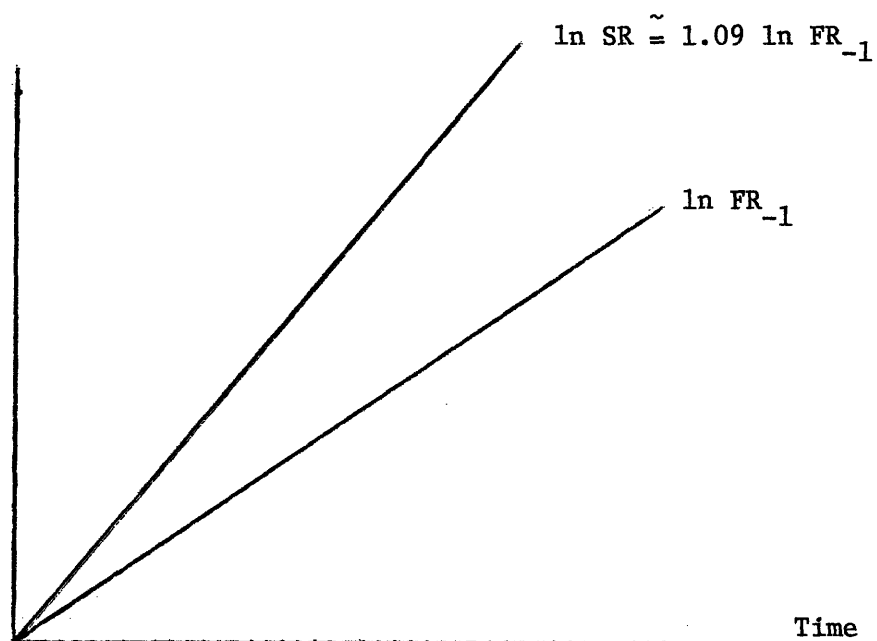
$$(7) \quad E[1/SR_t)/P_t^*] = E[1/FR_t)/P_t^*]$$

where P_t^* is the U.S. price level. Will these conditions be consistent with one another? They will be consistent in an important case: when purchasing power parity holds. If we can write the equation

¹ We can more easily understand how an equation with a slope coefficient "close" to one can be consistent with strongly biased [continued on next page]

Footnote continued from preceding page:

prediction and serially correlated prediction errors by looking at the following diagram:



Over time, the forward rate and the spot rate both grew, but the forward rate less. This caused large underpredictions even though the slopes were not very different, because of the huge growth. By allowing the slope coefficient in his regression to differ from one, Frenkel allowed it to "soak up" these prediction errors.

$$(8) \quad SR_t = KP_t/P_t^*$$

where K is an arbitrary constant, equations (7) and (8) imply each other.¹ The reason for this is that a world of purchasing power parity is effectively a one-good world, so that there is a unique definition of real profits.

When purchasing power parity holds, then, we can in principle test the rationality of expectations by using tests based on (7) or (8). Before proceeding to the empirical application of this result, which involves certain additional difficulties, it may be useful to look at a numerical example to see how various tests of rational expectations relate to one another. Table VIII considers a case in which there are two states of the world, which have equal probability of occurring. Prices are assumed known with certainty in the U.S., and the forward rate is such that the expected real profit on a forward contract is zero. A test on either the mark/dollar exchange rate or its log will tend to show the market underpredicting the future spot rate. Notice, however, that because U.S. prices are assumed certain a test on the dollar/mark rate would show unbiased expectations.

To implement tests based on real profits empirically, we first need to assure ourselves that purchasing power parity holds. A regression of the log of the mark/pound exchange rate on the log of the ratio of German to U.K. wholesale prices produces the equation listed as IX.1 in Table IX. The coefficient on prices is close to, although significantly different from, one. The large standard error, which has a percentage interpretation

¹ We have $E[SR_t/P_t] = E[FR_{t-1}/P_t]$ and $SR_t = KP_t/P_t^*$. Substituting, $E[K/P_t^*] = E[KFR_{t-1}/SR_t P_t^*]$. But since neither K nor FR_{t-1} are random variables, we can multiply by $1/KFR_{t-1}$ to derive $E[(1/FR_{t-1})/P_t^*] = E[(1/SR_t)/P_t^*]$.

Table VIII
 FORWARD MARKET UNDER PURCHASING POWER PARITY,
 NUMERICAL EXAMPLE

<u>State of World</u>	<u>I</u>	<u>II</u>
Probability	0.5	0.5
Exchange Rate, Dollars/Mark	0.5	1.5
Exchange Rate Marks/Dollar	2.0	2/3
Price Level in U.S.	1.0	1.0
Price Level in Germany	2.0	2/3

Forward rate, marks/dollar	= 1.0
Expected spot rate, marks/dollar	= 4/3
Log of forward rate	= 0.0
Expected log of spot rate	= 0.144

Table IX
FURTHER TESTS ON GERMANY

IX.1	$\ln SR = -.3820 + 0.9804 \ln(P/P^*)$ $(.0302) \quad (.0041)$
	$SEE = 0.1714 \quad R^2 = 0.9992 \quad D-W = 0.6766$
IX.2	$FR_{t-1}/SR_t = 0.7986$ $(.0637)$
	$SEE = .3601 \quad D-W = 1.3535$
IX.3	$FR_{t-1}/SR_t = 0.8941$ $(.0539)$
	$SEE = .2640 \quad D-W = 1.9618$
IX.4	$FR_{t-1}/SR_t = 0.5883$ $(.1650)$
	$SEE = .4950 \quad D-W = 0.8744$

Notes to Table IX: These equations have the following interpretations:

IX.1: SR = exchange rate, marks/dollar
 P = German wholesale price index
 P* = U.S. wholesale price index

The equation was estimated on monthly data, January 1920 to December 1923,
from the International Abstract of Economic Statistics, 1919-1930.

IX.2: SR = exchange rate, marks/pound sterling
 FR = forward exchange rate, pound sterling

The equation is estimated on data for the last week of each month from
February 1921 to September 1923. Data is from Einzig (1937).

IX.3 and IX.4: Same as IX.2, IX.3 is estimated for January 1921 to
December 1922; IX.4 for January - September 1923.

because of the log linear form somewhat compromises this result, however. It indicates that there were large fluctuations in relative goods prices, so that the assumption of a one-good world may not be appropriate.

Putting this difficulty on one side, however, let us proceed to test rational expectations as if purchasing power parity held. Here we run into a data difficulty. Our exchange rate numbers are end of month, but price data comes in monthly averages. Under hyperinflation conditions this can obviously make an important difference. There is an easy way out, however, If one of the currencies in the forward contract is relatively stable in real value, an approximately correct test for rationality would be that expected profits measured in the stable currency be zero. That is, if SR, FR are spot and forward rates in marks/pound, and the pound was fairly stable in value (as it was), an approximate test is

$$(9) \quad E[1/SR_t] = 1/FR_{t-1}$$

Since errors in (9) are unlikely to have constant variance, it seems preferable to think of the test as being of the equivalent proposition

$$(10) \quad E(FR_{t-1}/SR_t) = 1$$

We might note that if (10) were true, we would also have $\ln\{E[FR_{t-1}/SR_t]\} = 0$. Comparing this with the prediction error $\ln SR_t - \ln FR_{t-1}$, and remembering that minus log is a convex function, we can see that we would expect to find a positive average prediction error.

A test of (10) is reported in equation IX.2 in Table IX. The mean error is not as dramatic as in Table VII, but we can still clearly reject the hypothesis of unbiasedness. The bias, of 20 percent per month, is

still far too large to ascribe to risk or transaction costs.

Thus even when the forward market in marks is tested in a way that allows for large uncertainty, rational expectations does not stand up. Is there any way to salvage rational expectations? Two possibilities suggest themselves:

(i) Purchasing power risk: As pointed out above, the large standard error in equation IX.1 indicates that relative prices of German and foreign goods changed a good deal. In fact, the month-to-month uncertainty about relative goods prices must have been of the same order of magnitude as the uncertainty about the exchange rate. As a result, the tests are still subject to some bias. But the result in IX.2 can be looked at in a more literal way, which makes this an unconvincing explanation: IX.2 says that a British investor could have sold marks forward and earned an average 20 percent per month in pounds per pound of the contract.

(ii) Low probability events: A better defense of the market's rationality is to argue that the forward rate was kept below the spot rate, especially in the later stages, by the possibility of stabilization.¹ It is certainly true that the estimated bias is largely due to a series of large underpredictions in 1923. Equations IX.3 and IX.4 split the sample into two sub-samples, February 1921 - December 1922 and January - September 1923. It is apparent that looking at the first period alone gives a much more favorable result for rational expectations.

So it is at least possible that the bias in the forward rate was the result of market expectations of a stabilization; that the market correctly assessed the chances that the stabilization would occur; but that since we don't actually happen to observe a stabilization in our

¹ This possibility, and the difficulties it poses for testing market efficiency, were pointed out to me by Bill Krasker.

sample, expectations appear biased. Alternatively, speculators may just not have been able to believe in the magnitude of the depreciation (the forward discount never exceeded 36 percent per month). It is not clear how we might be able to tell the difference.

In this section, then, I have examined the problem of testing the rationality of the forward market in hyperinflation. The problem of uncertainty has a theoretically correct solution when purchasing power parity holds, and a workable approximate solution if one of the currencies has a fairly stable value. But the problem of low-probability events, in the form of stabilization, makes rational expectations ultimately untestable in the case studied.

IV. Summary and Conclusions

This paper began by noting that during periods of floating exchange rates there has been a widespread belief that speculation in the exchange markets plays a disruptive role, presumably because of irrational behavior on the part of speculators. The verdict of the empirical tests is ambiguous. During the 1920's speculation in the dollar and the franc seems to have been rational; special circumstances make the rationality of speculation in the mark hard to test. More recently, however, the forward market does not seem to have done so well. Only for the lira do we fail to reject rationality; the forward markets in the pound sterling and the mark have clearly done badly.

There does appear, then, to be some justification for central banks' distrust of private speculation in the exchange markets.

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ESSAY III

ARE FLOATING EXCHANGE RATES STABLE?

A THEORETICAL AND EMPIRICAL STUDY

Introduction

The case against flexible exchange rates has always rested in large part on the argument that speculation in the exchange markets can destabilize an otherwise stable economy. This argument passes through cycles of popularity. It was widely accepted a generation ago, fell out of favor in the postwar period, and has recently regained currency under the name of the "vicious circle" hypothesis.¹ Proponents of flexible rates have generally argued in opposition that profitable speculation always works with, not against, the underlying causes of exchange rate movements. This counter-argument is formalized in models in which market expectations are assumed to be "rational."²

One might have expected the recent transition to a system of floating rates to settle the question, but events have conspired to make it difficult to draw conclusions on the basis of recent experience. The consequences of floating rates since 1973 are difficult to disentangle from the effects of

¹The doctrine of the "vicious circle of prices and exchange rates," though widely discussed, has not at the time of writing made its way into the journals. The best-known exposition of the doctrine was in a speech by Bernard Clappier at the IMF Meeting in Manila, 1975. A brief discussion of the concept appears in the Economic Report of the President, 1977.

²Many authors have applied rational expectations to exchange rates. A short list would include Black (1973), Mussa (1976), Kouri (1976), Dornbusch (1976). Other papers are discussed in the survey by Isard (1977).

the increase in commodity prices and the recession of 1974-76. Furthermore, government intervention in and regulation of markets in countries experiencing exchange depreciation has been extensive, further obscuring the evidence on how markets function.¹

In this paper I reconsider the stability of floating exchange rates from a theoretical and empirical standpoint. The paper is organized in two parts. In the first part I review the theoretical arguments about exchange stability. A simple monetary model is developed, and it is shown that the stability of the exchange rate depends crucially on how speculators form expectations about future exchange depreciation. If they extrapolate from past depreciation, instability is quite possible. But it may be difficult to distinguish on the basis of casual observation between an economy suffering from an unstable speculative run and one in which speculators are acting rationally in the face of anticipated monetary expansion. I then consider the effects of lags in price adjustment on stability, and show that they can make the exchange rate either more or less stable, depending on where they arise.

The second part of the paper gives some empirical underpinnings to the argument by examining in detail a particular case in which exchange depreciation has often been alleged to have destabilized an economy: France in the 1920's. There are several reasons for choosing this episode. First, the evidence is relatively "clean"; the problems in interpreting recent experience discussed above can be avoided. Second, the French experience is of doctrinal importance, for it was Exhibit A in the classic indictment

¹For a discussion of policy under floating rates in five industrial countries, see Black (1977).

of flexible exchange rates by Nurkse (1944). Third, the French experience was one in which causation (in some sense; I will return to this point) seems to have run from exchange speculation to domestic events.¹ Finally, the large depreciation and inflation stopped short of hyperinflation, which may allow us to learn more about the structure of the economy than is possible when monetary events are more violent.²

The study of France in the 1920's sheds a good deal of light on the theoretical issues raised in Part I of the paper. A simple monetary model of the exchange rate turns out to be a much better approximation to behavior than earlier studies of the episode might have led one to suppose. There is some evidence of slow adjustment of prices, but the lags are not, apparently, very long.

On the question of stability, I find that, just as theory suggested, the evidence is consistent both with destabilizing speculative runs and with rational behavior in anticipation of monetary expansion. But the latter is both a more attractive hypothesis and more reasonable in the historical context, so that we can argue that on balance the evidence is that exchange speculation did not independently destabilize the economy.

¹ For the alleged causal role of speculation, see Dulles (1929), Nurkse (1944) and Aliber (1962).

² In his study of depreciation and inflation in Germany, Frenkel (1976) writes that "the rapid developments occurring during the hyperinflation prevented a detailed analysis of the channels of transmission among the various sectors of the economy."

I. Expectations, Exchange Depreciation, and Inflation

A. Stylized Facts

There have been two major episodes of floating exchange rates in this century: the period of inconvertibility following the First World War, and the continuing period of floating following the breakdown of the Smithsonian agreement in 1973. A review of macroeconomic behavior in the two episodes¹ suggests several "stylized facts" about flexible exchange rates which we would like theoretical models to respect. We will see further evidence on these points later, but for the time being I will simply assert the following:

(i) Over the long run -- which means here no more than a few years, since that is as long as the interwar experience with floating rates lasted -- there is a reasonably close agreement between money supplies and prices, on the one hand, and between relative inflation and exchange depreciation, on the other. So the central "monetary approach" propositions of purchasing power parity and the quantity theory of money are confirmed for the long run (or more accurately, the medium run).

(ii) As a short run matter speculation plays an important role in exchange rate determination. Large current exchange rate movements can be produced by expectations of future exchange depreciation. This suggests, though it does not prove, a high degree of substitutability and mobility of securities denominated in different currencies. It is also evident that

¹ Empirical studies of European countries in the 1920's include Keynes (1924), Young (1925), Dulles (1929), Graham (1930), Tsiang (1959), and Aliber (1962).

owners of securities actively consider the possibility of future changes in parity when allocating their wealth.

(iii) Also in the short run, casual observation suggests stickiness of some prices. Wages in particular appear to move sluggishly, retail prices less so, wholesale prices least. As a result, there are substantial deviations of the exchange rate from many measures of purchasing power parity in the short run. PPP appears, however, to be gradually restored following a disturbance.

Wholesale Prices in Gold

1913 or 1914 = 100

	France	U.K.	U.S.	Germany	Italy	Belgium	Coeff. of Var.	Highest/ Lowest
1926	119	154	143	134	132	122	.098	1.29
1927	128	149	137	138	140	122	.070	1.22
1928	129	146	140	140	134	123	.062	1.19
1929	126	139	138	137	130	123	.051	1.13

Source: Statistique Générale de la France (1932).

¹ This assertion may need some explanation and documentation. Suppose we were to take price indices for a number of countries with a common pre-war base year, and adjust by exchange rates to put them into a common unit of account, such as gold. PPP doctrine would then assert that these price indices in gold should be equal. A long-run PPP doctrine would argue that under conditions of monetary stability these indices tend to converge. The table above presents evidence that this did, in fact, occur. It gives wholesale price indices in gold with 1913 or 1914 = 100 for six countries from 1926-29, and computes two measures of their dispersion, the coefficient of variation, and the ratio of the highest to the lowest. By either measure, there was a marked reduction in dispersion during those years, lending support to a long-run purchasing-power-parity doctrine.

The long-run behavior of exchange rates, then, is easily understood in a monetarist framework. Speculation and the possibility of instability can also be readily introduced into a simple monetary model. Sticky prices pose a greater problem of analysis, however, since different stories about price adjustment which seem equally plausible can produce quite different behavior.

The approach I will take here is one of postponing difficulties. I will begin by developing a simple monetary model of exchange rates, and analyze the conditions under which real or apparent instability can develop. Only at that point will the complications of slow price adjustment be introduced, and their implications for the stability of the exchange rate be considered.

B. A Monetary Model of Exchange Rates¹

Much of the literature on speculation and instability in a monetary economy is based on the classic study of hyperinflation by Cagan (1956). Cagan's theoretical apparatus was designed with a closed economy in mind, even through his empirical analysis focused on fairly open economies; but under some special assumptions which Cagan himself made his analysis carries over unchanged to an open economy with a floating exchange rate. The crucial assumptions are that real output is exogenously given and that wealth does not affect the demand for money. If rigidity of prices or wages causes monetary shocks to have real effects, the exchange rate

¹ The model developed in this section follows closely the models of Bilson (1976) and Frenkel (1976).

becomes a real as well as a monetary variable and it is necessary to turn to the Keynesian analysis of Mundell (1961) and Fleming (1962). More subtly, if wealth affects the demand for money, the evolution of the exchange rate will depend on the balance of payments on current account as well as on expected inflation and the quantity of money.¹

If we suppress these potential complications by assuming full employment and a pure transactions demand for money, Cagan's hyperinflation model can be reinterpreted as a model of a floating exchange rate. We begin with a demand function for money:

$$(1) \quad m - p = k + \varepsilon y - \lambda r \quad \varepsilon, \lambda > 0$$

where m is the log of the nominal money supply, p the log of the domestic price level, y the log of real income (assumed exogenously given) and r the interest rate. The economy is assumed to be linked to the rest of the world by both trade and capital movements -- that is, there is arbitrage in both the goods market and the securities market. In both cases, the arbitrage is assumed to be perfect. In the goods market this means that we have purchasing power parity:

$$(2) \quad s = p - p^*$$

where s is the log of the exchange rate, domestic currency for foreign and p^* is the foreign price level. In the securities market we have the corresponding conditions of interest parity:

$$(3) \quad r = r^* + \delta$$

¹ An elegant model of wealth effects and the exchange rate is that of Kouri (1976).

where r^* is the foreign interest rate and δ the expected rate of depreciation of domestic currency.

Equations (1) - (3) can be solved to yield a "pseudo" reduced form expression for the exchange rate:

$$(4) \quad s = -k - p^* - \epsilon y + \lambda r^* + m + \delta$$

This is not a true reduced form in the econometrician's sense, because not all the variables on the right hand side can properly be regarded as exogenous. For a country small in world goods and asset markets, p^* and r^* can reasonably be considered given, but neither m nor δ can be treated as exogenous. As we will see, in France during the 1920's the situation of the government budget led to a short-run dependence of the money supply on the interest rate, which for expositional purposes can be represented as a simple supply function:

$$(5) \quad m = \bar{m} + \mu r \quad \mu > 0$$

In this case it is the shift parameter in the money supply function, \bar{m} , which should be regarded as exogenous.

Most important for an analysis of stability, however, is the determination of δ . In the next section I turn to some simple hypotheses about how speculators form expectations and their implications.

C. Exchange Rate Expectations: AD HOC Formulations

To complete the model we need to know how the market forms an expectation about the rate of depreciation, δ . Much of the discussion of exchange

rate behavior involves some sort of ad hoc formulation in which investors form expectations about future exchange rates on the basis of past exchange rates in some plausible way. Two popular hypotheses are that:

(i) Investors regard some particular exchange rate as normal, and expect the rate to move back toward that normal level;

(ii) Investors extrapolate from past depreciation to predict future depreciation.

I examine a version of each of these hypotheses, which we can call "regressive" and "extrapolative" expectations, respectively, reserving a discussion of the more sophisticated hypothesis of "rational" expectations for the next section.

1. Regressive expectations: We suppose that the market always has in mind a normal exchange rate, σ , toward which it expects the actual rate to move. The expected rate of depreciation can be written

$$(6) \quad \delta = A_s (\sigma - s) \quad A_s > 0$$

Clearly, as long as the market's idea of what rate is normal doesn't change, speculation will not lead to any cumulative process of depreciation. Indeed, the effect of speculation will be to reduce the impact of shocks on the exchange rate. We can substitute into the reduced form (4) to derive the expression:

$$(7) \quad s = [1/(1 + A_s)] [-k - \epsilon y + m + \lambda r^* + \lambda A_s \sigma]$$

from which it can be seen that the effects of all factors on the exchange rate are dampened.

2. Extrapolative expectations: Matters look quite different when the market extrapolates from past currency depreciation. Suppose, now, that the expected rate of depreciation, δ , is gradually adjusted in the direction of the actual rate, so that, introducing time subscripts, we have:

$$(8) \quad \delta_t - \delta_{t-1} = \theta[(s_t - s_{t-1}) - \delta_{t-1}]$$

or
$$\delta_t = \theta(s_t - s_{t-1}) + (1 - \theta)\delta_{t-1}$$

Substituting back into (4), and now also taking account of the endogenous money supply as represented in (5), we can derive the result that actual depreciation is proportional to the change in the expected rate of depreciation:

$$(9) \quad s_t - s_{t-1} = (\lambda + \mu) [\delta_t - \delta_{t-1}]$$

But actual depreciation feeds back into expectations, and there is no guarantee the process is stable. From (8) and (9) we have

$$(10) \quad \delta_t = Z \delta_{t-1}$$

where
$$Z = \frac{1 - \theta - \theta(\lambda + \mu)}{1 - \theta(\lambda + \mu)}$$

Obviously, (10) will be unstable if $|Z| > 1$. There are two cases of instability:

(i) If $\frac{1}{2} \theta[1 + 2(\lambda + \mu)] > 1 > \theta(\lambda + \mu)$, there will be oscillations

of increasing size around $\delta = 0$. It is hard to attach much economic meaning to this case, which would not occur if we had worked, as Cagan (1956) did, in continuous time.¹

(ii) Of more significance is the case when $\theta(\lambda + \mu) > 1$, so that $Z > 1$. In that case, δ will explode, with depreciation inducing expectations of further depreciation, causing a cumulative "flight from the currency." It is worth looking at this case more closely. The path of the expected rate of depreciation, from (10), will be exponential:

$$(11) \quad \delta_{t+i} = Z^i \delta_t$$

The exchange rate will depreciate at an accelerating rate. Let \bar{s} be the solution for s when $\delta = 0$. Then the exchange rate will depreciate according to

$$(12) \quad s_{t+i} - \bar{s} = Z^i (s_t - \bar{s})$$

Extrapolative expectations, then, create the possibility of instability. An unstable speculative run is more likely, the faster expectations adjust; the greater the sensitivity of money demand to the interest rate; and the more accommodating the monetary authority, as measured by μ . As we will see below, stability can also depend on the way prices lag behind the money supply and/or the exchange rate.

D. Rational Expectations

An important objection to hypotheses about expectations like those considered in the last section is that in such formulations investors are

¹ Cagan did, however, use a discrete time formulation for empirical work; as a result, his tests of stability are not strictly valid.

assumed to hold beliefs about the future course of exchange rates which are in fact incorrect. During a speculative run of the kind represented by equations (11) and (12), for example, the actual rate of depreciation will always exceed the expected rate. An increasingly popular alternative to such ad hoc hypotheses argues that investors will be as well-informed as the economist modeling them, so that their predictions are the same as those of the model. The hypothesis of "rational expectations" would imply that, except at those moments when the market has just received new information,¹ the expected rate of depreciation is the same as the actual rate. Note that the relevant period is from the purchase of a security until it comes due, so that if δ is the expected one-period rate of depreciation, we have:

$$(13) \quad \delta_t = s_{t+1} - s_t$$

But we have already noted that $s_{t+1} - s_t = (\lambda + \mu) [\delta_{t+1} - \delta_t]$, so the expected rate of depreciation will follow an exponential path:

$$(14) \quad \delta_{t+1} = \frac{1 + \lambda + \mu}{\lambda + \mu} \delta_t$$

Since the coefficient on δ_t is greater than one, like the case of unstable extrapolative expectations, the rational expectations model appears to exhibit knife-edge instability. Unless the initial expected rate of depreciation is zero, (14) implies explosive divergence.

¹ In this paper I deal with uncertainty by assuming that individuals make plans as if they were perfectly certain about the future. When new information becomes available, they revise their plans, but again plan as if they were certain. For the purposes of this paper an explicit consideration of uncertainty would complicate the exposition without making much difference.

But nothing has so far determined the initial value of δ . In fact, we may argue that if investors do not believe in the possibility of indefinite speculative bubbles, the initial value of δ , and hence also of the exchange rate, will be determined precisely by the requirement that the subsequent path of the economy converge to equilibrium.¹ Thus, we assume that $\delta = 0$ unless the equilibrium exchange rate is itself changing, so that speculation never acts as an independent destabilizing force. The rational expectations approach may be regarded as a formal statement of the argument of Keynes (1924) that "the successful speculator makes his profit by anticipating, not by modifying, existing economic tendencies," under the assumption that speculators are, as a rule, successful.

Rationality of expectations does not, however, mean that exchange rates cannot be volatile. If the underlying variables determining the equilibrium rate shift around, so will the actual rate. The most important of these is of course the money supply function. Furthermore, expectations of future changes in the exchange rate can affect the current rate. An important implication of the model is that under rational expectations the behavior of exchange markets in response to an anticipated monetary expansion can appear on casual inspection to be destabilizing. Suppose, in particular, that investors come to believe that the monetary authority will alter its behavior at some future date, increasing the supply of money at any given interest rate. This will lead to a current depreciation of the currency and then to continuing depreciation and rising domestic prices in a sequence of events quite similar to what one would expect to

¹ For a justification of this assumption, see Brock (1975).

observe in an irrational "flight from the currency" of the kind discussed above.

The way such a depreciation would work may be examined more carefully if we solve for the path of the exchange rate under rational expectations. Let \bar{s} be the exchange rate which would obtain if no depreciation were expected, i.e., the solution of (4) and (5) when $\delta = 0$. For expectations to be fulfilled, any path for the exchange rate must obey the difference equation

$$(15) \quad s_{t+1} = \bar{s} + \frac{1 + \lambda + \mu}{\lambda + \mu} (s_t - \bar{s})$$

As long as the underlying factors determining \bar{s} are not expected to change, the only path which obeys (15) and does not involve unlimited "tulipmania" is where s is stationary at \bar{s} . This is illustrated by point A in Figure I.

Now suppose that at time t new information leads investors to expect a monetary expansion at a later date, say $t + T$, which will increase the equilibrium exchange rate, say to that depicted as point C. Then we know that after $t + T$ the economy will be at the new equilibrium.

But the exchange rate must not be expected to make a discrete jump at $t + T$. If it were to jump, that would involve a windfall capital gain, something ruled out by arbitrage. Any jump in s over and above that allowed by the arbitrage condition (15) must come at the moment when the information available to the market changes, that is, at time t . The path of the economy thereafter must be one which arrives at C at time $t + T$ without there having been any further windfall capital gains.

In Figure I, such a path would involve an initial jump in s to a point like B, then gradual further depreciation to C. (As Brock (1975) has

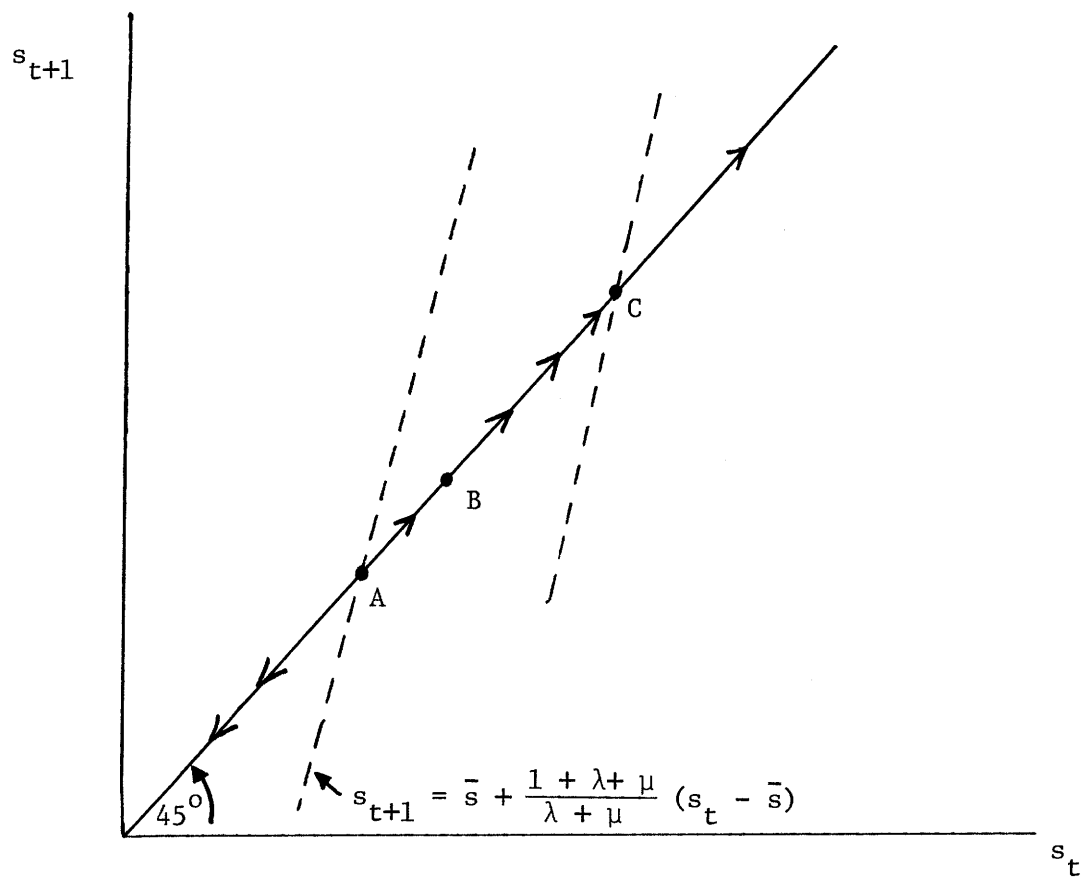


Figure I

shown for a closed economy, all adjustment to an anticipated monetary expansion must take place before the expansion itself takes place.)

The size of the initial jump to B is determined by the necessity that the time taken to traverse BC be exactly T periods.

The important point to note is how much a depreciation in anticipation of monetary expansion looks like a destabilizing speculative run. Along BC the behavior of the expected rate of depreciation and the exchange rate are described by (14) and (15), which are identical in form to the process of depreciation described by (10). One might easily imagine that an observer could misinterpret the sequence of events, or that an econometrician might get a good fit with an extrapolative model even where it was inappropriate. I will argue that something along these lines has occurred in the interpretation of events in France in the 1920's.

Is there any way to distinguish empirically between "rational" depreciations in anticipation of monetary expansion and extrapolative expectations? If we can directly observe expectations in the form of forward contracts, there is a simple test: in a speculative run investors will make persistent prediction errors; in a rational depreciation they will not.

E. Lags in Price Adjustment

The discussion of stability to this point has been confined to a model in which prices are assumed to adjust instantaneously to clear markets. This may seem an unrealistic assumption to make in a short-run context. Nor is it a harmless simplification, if it is wrong, for as Dornbusch (1976) has argued, slow adjustment of prices can make a great deal of difference to the behavior of exchange rates. Unfortunately, it is not easy to

determine just what kind of difference it makes, since whether slow price adjustment stabilizes or destabilizes the exchange rate depends on the nature of the lag. If the lag is principally a lag of prices behind the exchange rate, the effect will be destabilizing.

We can illustrate this point by comparing the monetary model of this part of the paper with an extreme Keynesian model in which prices are entirely rigid.¹ Such a model would substitute variations in output for variations in domestic prices. Let us assume that the economy can be represented by the following model:

$$(16) \quad Y = C(Y) + I + T(s - p, Y) \quad (\text{goods market})$$

$$0 < C_1 < 1, \quad T_1 > 0, T_2 < 0$$

$$(17) \quad m - p = L(Y, r) \quad (\text{money market})$$

$$L_1 > 0, L_2 < 0$$

$$(18) \quad r = r^* + \delta \quad (\text{capital mobility})$$

where

Y = real output

C = real consumption

I = investment, treated as exogenous

T = trade balance, measured in domestic goods

s = log of exchange rate

¹ In the appendix to this part of the paper I show that introducing gradual price adjustment does not alter the conclusions.

p = log of domestic price level, assumed fixed

m = log of money supply

r = domestic interest rate

r^* = foreign interest rate

δ = expected rate of depreciation

We can examine the stability of this economy under the assumption of extrapolative expectations, which I will represent in continuous time here to simplify the analysis:

$$(19) \quad \dot{\delta} = A_{\delta}(\dot{s} - \delta) \quad A_{\delta} > 0$$

In this model, as in the earlier model, expectations of future depreciation will induce current depreciation, a process which can be explosive. If it is to be stable, depreciation must work sufficiently powerfully through the trade balance and thence through increased real income to raise the interest rate. The necessary and sufficient condition for stability is $A_{\delta} \cdot \left(-\frac{\partial m}{\partial r}\right) \cdot \frac{1 - C_1 - T_1}{L_1 T_1} < 1$. This compares with a stability condition under flexible prices and purchasing power parity of $A_{\delta} \left(-\frac{\partial m}{\partial r}\right) < 1$. The rigid-price model may be either more or less stable than the flexible price model.

Whether it is less stable depends on the strength of the stabilizing forces, in particular, the effect of the exchange rate or the trade balance. If T_1 is large, which is also a condition under which purchasing power parity will remain a good approximation, rigidity of prices will have a stabilizing effect. If it is small, sticky prices will make the economy more prone to speculative runs.

Unfortunately, then, the plausible statement that prices adjust slowly has ambiguous implications for the stability of a floating exchange rate system. The effect depends both on the price elasticities of trade flows and on the multiplier effect of the trade balance on income, both of which are notoriously hard to pin down empirically.

F. Summary

In this part of the paper I have examined the question of exchange stability in the context of a monetary model of exchange rates which draws upon the work of Cagan (1956) and Brock (1975). From this model, and some extensions to situations in which prices do not adjust instantaneously, four major conclusions emerge:

(i) If expectations about future exchange rates are regressive, the economy is always stable.

(ii) The possibility of instability arises when investors extrapolate from past exchange rate changes, creating the possibility of a cumulative process of flight from the currency.

(iii) The likelihood of instability given extrapolative expectations depends on the structure of the economy and the behavior of the monetary authority as well as the speed with which expectations adjust.

(iv) Finally, if expectations are formed rationally, the economy is always stable. But rational expectations are consistent with volatile exchange rates. And it is possible under rational expectations for speculation to play a leading role in a chronological sense in a process of inflation and monetary expansion, which may make it difficult to distinguish between a "rational" depreciation in anticipation of a change in

monetary policy and an irrational flight from the currency arising from extrapolative expectations.

These results come from a particular model; but their special character should not be overemphasized. They look, instead, as if they should be quite generally true.

APPENDIX TO PART I

STABILITY IN A KEYNESIAN MODEL

In Section E of this part of the paper I dealt briefly with the effects of sticky prices on exchange stability. The model used there involved an assumption of completely rigid prices. I extend the analysis here to the case of gradually adjusting prices.

Restating the model, we have:

$$(A1) \quad Y = C(Y) + I + T(s - p, Y)$$

$$(A2) \quad m - p = L(Y, r)$$

$$(A3) \quad r = r^* + \delta$$

To this we add a simple price adjustment equation: we assume that prices adjust gradually in the direction of the long-run equilibrium price, \bar{p} :

$$(A4) \quad \dot{p} = A_p(\bar{p} - p)$$

If expectations are formed extrapolatively, we add to these equations the expectations equation

$$(A5) \quad \dot{\delta} = A_{\delta}(\dot{s} - \delta)$$

To examine the stability of this system, we can linearize around $\delta = 0$ and the long-run equilibrium value of p , \bar{p} , to derive the dynamic system

$$(A6) \quad \begin{bmatrix} \dot{p} \\ \delta \end{bmatrix} = \begin{bmatrix} -A_p & 0 \\ B^{-1} \left(\frac{1-Z}{Z} \right) \left(\frac{\pi_1}{L_1} \right) & -B^{-1} \end{bmatrix} \begin{bmatrix} p - \bar{p} \\ \delta \end{bmatrix}$$

where

$$B = 1 + A_{\delta} L_2 / Z$$

$$Z = \frac{L_1 T_1}{1 - C_1 - T_2}$$

Necessary and sufficient conditions for stability are that the trace of the matrix in (A6) be negative and its determinant positive. Both will be satisfied if and only if $B > 0$, that is if

$$-A_{\delta} L_2 / Z < 1$$

But this is the same stability condition derived in the case of the model with completely rigid prices.

II. Empirical Evidence: France in the 1920's

In Part I of this paper I showed that the stability of a flexible exchange rate regime cannot be determined a priori: we need to know how asset markets behave, and may need to know a good deal about the structure of an economy and the behavior of the monetary authority, before we can reach a conclusion about stability. I therefore turn to some empirical evidence: an examination of the French experience with floating exchange rates in the 1920's. This experience was regarded by Nurkse (1944) and Aliber (1962) as one of the major examples of the instability of a flexible rate regime. While the central concern of the analysis will be with the question of stability, a number of other questions inevitably arise, making this section into a fairly extensive investigation of the working of an economy under flexible rates. The analysis is organized in five sections. Section A gives an overview of monetary developments in post-World War I France, and defines the issue of stability. Section B is concerned with the role of prices in the process of depreciation. It examines the usefulness of the purchasing-power-parity hypothesis, then turns to the determination of domestic prices and wages. In Section C the working of the foreign exchange market is considered, and some hypotheses about it tested. Section D looks at the domestic monetary process, both the demand for money and the determinants of its supply. Finally, Section E pulls together the evidence and attempts to give a coherent account of what happened in France in the twenties.

A. Overview

Without doing too much violence to the facts, one can divide the monetary history of France in the 1920's into three distinct periods. From soon after the unpegging of the franc in 1919 until late 1922, the value of the franc was fairly stable. There was little speculation against the franc; indeed, in the early postwar period the franc was generally expected to appreciate. During 1923-26, however, the franc began depreciating at a rate substantially in excess of current monetary expansion. There were two sudden speculative "attacks" on the franc, in the winter of 1923-24 and the summer of 1926. At the height of the latter crisis a new government was formed, which introduced a period of a stabilized exchange rate which passed imperceptibly into the restoration of the gold standard in 1928.

Some of the relevant statistics for 1920-27 are given in Table I. It is apparent from columns (1) and (2) that depreciation and relative inflation were of comparable size, although there was some tendency for inflation to outstrip the exchange rate from 1920 to 1922, and the converse thereafter.¹ Columns (3) and (4) provide evidence on the willingness of the public to hold francs. In the early postwar years, French interest rates were lower than U.K. rates, but French securities nonetheless found buyers because the depreciation of the franc was widely regarded as temporary.² This situation was reversed as investors began to expect

¹ It should also be noted that the franc remained "undervalued" throughout the 1920's if 1913 or 1914 prices are used to compute the purchasing power parity.

² Thus Keynes (1924), condemning the tendency of the French authorities to blame their difficulties on speculation, asserted that during the postwar years to that date there had been more speculation in favor of the franc than against it.

Table I

FRENCH STATISTICS, 1920-1927
(1920 = 100)

	(1)	(2)	(3)	(4)
	<u>Exchange Rate, Francs/Pound</u>	<u>Purchasing Power Par</u>	<u>Real Value of Note Circulation</u>	<u>Bank Rate Parity Against London</u>
1920	100.0	100.0	100.0	- 1.00
1921	99.2	107.3	143.7	- 0.25
1922	103.8	126.2	146.3	+ 1.46
1923	144.5	161.2	117.7	+ 1.50
1924	162.1	177.8	108.5	+ 2.08
1925	194.6	208.5	106.4	+ 1.92
1926	287.8	288.7	101.0	+ 1.67
1927	238.0	263.3	116.1	+ 0.50

(1) Exchange rate, francs/U.K. pound. Source: Banking and Monetary Statistics, 1914-1940.

(2) Ratio of French to U.K. wholesale prices. Source: European Historical Statistics.

(3) Ratio of note circulation to wholesale price index. Source: Ibid.

(4) Average annual excess of French over U.S. bank rate. Source: Einzig (1937).

continuing depreciation of the franc. Then a combination of relatively high interest rates in France and restrictions on export of capital¹ were necessary to make investors willing to hold franc-denominated securities. This unwillingness to hold francs is also shown by the real value of note circulation, which fell from 1922 on even though real output was rising.

This much is not a matter for dispute. The crucial question is, what caused the change in expectations? Most writers on the French experience, most notably Nurkse (1944) in his celebrated attack on flexible exchange rates, have argued that exchange markets behaved in a more or less irrational manner, and that France was the victim of a large-scale speculative run. It is probably fair to regard this as the traditional view. In this paper I will make a case for an alternative explanation, that markets behaved in a rational manner, and that the change in expectations was a response to new information that led investors to believe that future monetary expansion was likely.

The traditional account of the French experience, as developed by Nurkse and elaborated by Aliber (1962) may be expressed schematically in terms of the model of Part I. In the early postwar period, wrote Nurkse, "there was a strong belief that the depreciation of European currencies was a purely temporary phenomenon...and that these currencies would sooner or later return to their pre-par parities." In short, expectations may be

¹ The French government imposed a number of restrictions on the acquisition of foreign assets, as described in Dulles (1929). It is evident that many investors were able to avoid these restrictions by altering the location of trade finance, accelerating repayment on foreign loans, and other measures, including, Dulles reports, smuggling coins out of the country in cheeses.

described as having been regressive, and thereby tending to stabilize the currencies.¹ As time passed without any tendency to return to pre-war parity, however, the process by which expectations were formed was revised, and the exchange market became dominated by extrapolative expectations, which destabilized the economy. "Anticipatory purchases of foreign exchange tend to produce or at any rate to hasten the anticipated fall in the exchange value of the national currency, and the actual fall may set up or strengthen anticipations of a further fall."

Aliber (1962) elaborated further on the reasons why the French economy was unstable, and though his paper avoids writing any explicit model he stressed the lag of prices behind the exchange rate and the elasticity of money supply with respect to the interest rate, corresponding to the factors making for instability in the discussion of Part I.

What would an alternative explanation of the depreciation of the franc look like? I will argue that much of the behavior of the markets in France suggests that investors' expectations were not so much based on past behavior of the franc as on the political situation. The key factor causing movements in the exchange rate was political news altering the market's beliefs about the extent to which the government was likely to meet its financial difficulties by money creation. The relevant model in this case, assuming that market anticipations were on average correct, would be that of rational expectations, and in particular the case discussed above in which the market expects future monetary expansion.

¹ Nurkse argued that there were nonetheless forces tending to produce continuing depreciation. Following Polak (1943), he argued (in modern terminology) that imperfect substitutability between assets required that currencies depreciate as external debt increased via current account deficits.

It is not possible to settle which of these two views is more nearly correct on the basis of casual observation. We need to know a good deal of detail about how the French economy actually behaved during the period. The questions which need to be answered are the following:

(i) Are the traditional assertions about the price mechanism accurate? I.e., is it appropriate to dismiss a simple purchasing power parity explanation of depreciation?

(ii) How did the asset markets actually behave? Can the formation of expectations be represented by an extrapolative scheme; or were expectations "rational"?

(iii) Since in the end France did experience a large increase in the money supply, what was the process through which this occurred?

In the discussion that follows I examine each of these points.

B. Price Behavior

An important aspect of much discussion of exchange rates is the assertion that, while there is a long-run tendency for purchasing power parity to hold, it does not hold in the short run. We would like to know the extent to which the exchange rate can live a life of its own; how significant are the deviations from purchasing power parity?

There are several ways one might go about assessing purchasing power parity as a theory. One way to judge a theory is by how much it explains; is the variance of the exchange rate when corrected by relative prices much less than the variance of the exchange rate itself? Another, different question to ask is whether the deviations from purchasing power parity are systematic. E.g., are they white noise, or are they highly serially

correlated? As it turns out, PPP does well by the first criterion, but less well by the second.

Before proceeding to test purchasing power parity, it is important to be clear what PPP is. It is not a causal theory; in the monetary model developed in Part I, neither the exchange rate nor the price level can be regarded as a causal variable; rather, PPP is best viewed as an arbitrage condition, part of a larger model. For purposes of statistical testing, this means that we must be prepared to regard relative prices as simultaneously determined, and to apply appropriate methods.

Table II reports the results of a number of tests of purchasing power parity, using monthly British and French data for the period December 1921 to December 1926. Equations II.1 and II.2 directly test the proposition that exchange rate changes should be proportional to differential inflation. In an equation of the form $s = \alpha + \beta (p - p^*)$ where s is the logarithm of the exchange rate, p the log of the domestic price level, and p^* , the log of the foreign price level, PPP predicts $\beta = 1$. II.1 and II.2 estimate this equation by instrumental variables, since ordinary least squares would be subject to the problems of simultaneity mentioned above. The problem of finding instruments is simplified by the fact that $p - p^*$ is strongly trended, so that a time trend will serve. In II.1 the purchasing power par is measured by wholesale prices, in II.2 by retail prices. When wholesale prices are used the value of β is not too far from one; the results look less good when retail prices are used. We cannot easily test whether the differences from one are significant, however, since the Durbin-Watson statistics suggest fairly high serial correlation in the residuals.

Table II
TESTS OF PURCHASING POWER PARITY

Equation	Dependent Variable	Independent Variable	α	β	SEE	R^2	D - W	$\hat{\rho}$
II.1	S	WPI - WPI*	-.034 (.009)	1.206 (.017)	.036	0.99	0.97	--
II.2	S	RPI - RPI*	.085 (.021)	1.522 (.061)	.106	0.91	0.46	--
II.3	S	WPI - WPI*	-.036 (.017)	1.203 (.031)	.032	0.99	--	0.513
II.4	S	RPI - RPI*	.145 (.080)	1.286 (.196)	.068	0.96	--	0.821
II.5	S + WPI* - WPI	--	.061 (.033)	--	.037	--	--	0.854 (.067)
II.6	S + RPI* - RPI	--	.245 (.074)	--	.066	--	--	0.885 (.060)

Notes: The equations are estimates of $y = \alpha + \beta x$, where y is the dependent variable and x is the independent variable. Equations II.1 and II.2 are estimated by two-stage least squares, using a constant and a time trend to form the instruments. Equations II.3 and II.4 are estimated by a combination of two-stage least squares and the Cochrane-Orcutt iterative procedure, with $\hat{\rho}$ the estimated coefficient of serial correlation. II.5 and II.6 have no independent variable; the mean α and the coefficient of serial correlation are estimated by Cochrane-Orcutt.

Notes to Table II (continued):

The variables have the following definitions: S = log of spot exchange rate, francs/pound; WPI = log of wholesale price index, France; WPI^* = log of wholesale price index, U.K.; RPI = log of retail price index, France; RPI^* = log of retail price index, U.K. Source: Exchange rates are monthly averages from Einzig (1937). Prices are from International Abstract of Economic Statistics, 1919-1930. All regressions are run over the period December 1921 to December 1926.

Equations II.3 and II.4 test purchasing power parity under the assumption that errors are subject to first-order serial correlation. When retail prices are used as a measure of the purchasing power par we cannot reject the hypothesis $\beta = 1$. When wholesale prices are used the difference of estimated β from one is significant; on the other hand, it is not very large. Serial correlation of the errors is moderate when wholesale prices are used, higher when retail prices are used, but in neither case can the serial correlation be regarded as very severe when one bears in mind that we are dealing with monthly data.

Another test is reported as II.5 and II.6. Here we constrain $\beta = 1$, estimating the equation $s + p - p^* = \alpha$. In this case the errors can be interpreted as deviations from PPP, and the serial correlation measures the persistence of these deviations. Serial correlation is more severe here; the reason is presumably the tendency of the exchange rate to drift upward relative to the purchasing power par over the sample period, a drift which is captured in II.1 - II.4 by coefficients on prices exceeding one.

It is clear from the high values of R^2 in II.1 - II.4 that there is a strong association between price movements and exchange rates. Another indication of the considerable truth in PPP is given by comparing the variance of the exchange rate itself with the variance of the exchange rate deflated by relative prices. Over the period December 1921 to December 1926, the variance of the log of the exchange rate deflated by relative retail prices was only 18 percent of the variance of the log of the unadjusted exchange rate. The log of the exchange rate adjusted by wholesale prices had a variance only 6 percent of that of the unadjusted rate.

On this evidence, then, purchasing power parity does not seem to fare too badly. Why, then, has PPP been so quickly dismissed by many studies of the French experience? The answer is presumably that one can find examples of substantial slippage for short periods between the exchange rate and relative prices. For example, when a government austerity program coupled with new foreign loans caused an abrupt revival of confidence from March to April of 1924, the exchange rate fell by 26 percent, while relative wholesale prices fell only 11 percent and relative retail prices fell only 3 percent. Episodes like this suggest some sort of a lag of prices behind the exchange rate.

Table III reports on some crude tests for such a lag. It shows that simple statistical analysis confirms the casual impression of lags in price adjustment; but further analysis indicates that, when PPP is measured by wholesale prices, at least, the apparent lag may be an optical illusion resulting from simultaneity (and possibly also from measurement errors).

The equation estimated in regressions III.1 - III.4 is $p_t - p_t^* = \alpha + \beta s_t + \gamma(p_{t-1} - p_{t-1}^*)$, where s , p , and p^* have the same definitions as in Table II. A positive value of γ would be evidence of a tendency of prices to lag the exchange rate. Equations III.1 and III.2 show evidence for such a lag -- a short lag for wholesale prices, a much longer lag for retail prices -- even when allowance is made for the presence of first-order serial correlation. But when we apply an instrumental variable approach, in equations III.3 and III.4, the evidence for a lag in wholesale prices disappears. The lag in retail prices gets shorter, although it remains significant.¹

¹ We should note that a lag of prices behind exchange rate changes is not necessarily evidence of price rigidity in the sense of a failure of prices to clear markets. If a price index contains non-traded goods, it may be less volatile than the exchange rate because the wealth effects of exchange rate changes affect the relative price of non-traded goods. Thus in the popular money and home goods model, devaluation is less than fully reflected in internal depreciation.

Table III
TESTS FOR PRICE LAGS

<u>Equation</u>	<u>Price Variable</u>	<u>α</u>	<u>β</u>	<u>γ</u>	<u>SEE</u>	<u>R^2</u>	<u>$\hat{\rho}$</u>
III.1	WPI	.033 (.007)	.536 (.045)	.334 (.054)	.020	.995	0.345
III.2	RPI	-.006 (.006)	.118 (.025)	.842 (.038)	.020	.993	0.153
III.3	WPI	.033 (.019)	1.054 (.394)	-.263 (.454)	.037	.984	0.532
III.4	RPI	-.013 (.009)	.170 (.057)	.766 (.083)	.021	.992	0.264

Notes: These are estimates of the equation $p_t - p_t^* = \alpha + \beta s_t + \gamma(p_{t-1} - p_{t-1}^*)$ where p is the log of the French price level, p^* the log the U.K. price level, and s the log of the franc/pound exchange rate. "WPI" indicates that whole-sale prices are used, "RPI" that retail prices are used. Equations III.1 and III.2 are estimated by Cochrane-Orcutt. Equations III.3 and III.4 are estimated by a combination of two-stage least squares and Cochrane-Orcutt, using a time trend and $(p_{t-1} - p_{t-1}^*)$ to form instruments.

For data sources, see Table II.

The evidence of this section is more favorable to purchasing power parity than received opinion would have led us to expect. One can make a fairly good case that wholesale price parity held continuously. While the same cannot be said for retail prices, there is nothing to suggest a serious failure of the price system to work.

C. Exchange Rates and Expectations

The central issue in analyzing the depreciation of the franc is the question of exchange rate expectations. Our interpretation of the speculation against the franc depends crucially on whether speculators were behaving in an irrational fashion, on one side, or were making sophisticated predictions taking the structure of the economy into account, on the other.

Let us begin by considering the possibility that expectations were formed by extrapolating from past depreciation. This was written in Part I as:

$$(8) \quad \delta_t = \theta(s_t - s_{t-1}) + (1 - \theta) \delta_{t-1}$$

$$\text{or} \quad \delta_t - \delta_{t-1} = \theta[(s_t - s_{t-1}) - \delta_{t-1}]$$

where δ is the expected one-period rate of depreciation.

To estimate (8), we need to be able to observe the expected rate of depreciation, δ_t . I will assume that expected depreciation can be measured by the forward discount on the franc on the London market. This means ignoring the possible roles of transaction costs and risk. The direction of bias caused by these omissions is unclear.

Table IV shows the results from a number of estimates of (8) by varying

Table IV
EXTRAPOLATIVE EXPECTATIONS

Equation	Estimation period	γ	SEE	SSR	D - W	R^2	$\hat{\rho}$
IV.1	Feb.1922- Dec.1926	.0332 (.0069)	.0038	.000818	2.249	.2874	--
IV.2	Feb.1922- June 1924	.0334 (.0111)	.0044	.000554	2.545	.2446	--
IV.3	July 1924- Dec.1926	.0330 (.0081)	.0030	.000265	1.573	.3628	--
IV.4	Mar.1922- Dec.1926	.0279 (.0064)	.0037	.000789	--	.3126	-.213
IV.5	Mar.1922- June 1924	.0152 (.0084)	.0040	.000435	--	.4066	-.547
IV.6	July 1924- Dec.1926	.0346 (.0084)	.0030	.000254	--	.3885	.203

Notes: These are all estimates of

$$d_t = \gamma[(s_t - s_{t-1}) - d_{t-1}], \text{ where}$$

d_t = 30 day forward discount on the franc, London

s_t = monthly average log of the exchange rate, francs/pound

Equations IV.1-IV.3 were estimated by OLS, while IV.4-IV.6 were estimated by Cochrane-Orcutt. Exchange rates and forward rates are from Einzig (1937).

techniques and over varying sample periods. Regression IV.1 is the basic estimate, by ordinary least squares over the whole 1922-26 period. The estimate of θ is .0332, which may, as will be shown later, have been large enough to have produced instability in the French economy.

The remaining estimates in Table IV are tests designed to probe for weaknesses in the basic estimate. We might suspect that a simple expectations formulation like (8) would appear to work well for any given set of observations, but would be sensitive to the particular set of data. To test this, the time period was arbitrarily cut in half and separate regressions IV.2 and IV.3 were run. Obviously, the estimates of θ hardly differ at all; not surprisingly, an F-test of equality of θ across the regressions fails to reject at the 95 percent level.

The last three regressions in Table IV test for the possibility of misleading results due to serial correlation. IV.4 estimates (8) by Cochrane-Orcutt; this makes little difference to θ , while an asymptotic t-test fails to reject $\rho = 0$ at the 95 percent level. If we nonetheless proceed to estimate for sub-periods, some evidence of instability in the parameters appears. Over the first half of the sample the coefficient of extrapolation is relatively small, and there is significant negative serial correlation -- the extrapolative hypothesis does not appear to work too well over this period. A likelihood-ratio test of the equality of θ and ρ across the sub-periods leads to rejection at the 95 percent level.¹

A simple extrapolative scheme, then, appears on first inspection to work quite well, although some problems appear on closer examination.

¹ The test statistic is $-2 \log L$, where L is the likelihood ratio; this is distributed as $X^2(2)$ under the null hypothesis. The value of the statistic is 8.42, where the 95 percent level of the chi-squared test is 5.99.

Even if these problems were not there, however, it would be a mistake to quickly accept that expectations were actually formed extrapolatively. As I have already emphasized, it is possible for extrapolative expectations to look like the appropriate explanation when the actual process by which expectations are formed is more sophisticated. And this caution is justified in this case; for while extrapolative expectations appear to fit quite well, the evidence is also consistent with rational expectations.

Table V presents a series of tests of rational expectations. They are based on the "efficient markets" hypothesis that the forward rate at time t contains all the information available to investors at that time about the spot rate at time $t + 1$. This has a number of implications, which are tested in succession.

(i) The forward rate must be an unbiased predictor of the spot rate when contracts come due, i.e., $E(s_t - F_{t-1}) = 0$; this is tested and not rejected in V.1.

(ii) There must be no information from past prediction mistakes about future mistakes. If we choose periods so that forward contracts do not overlap, this implies no serial correlation in prediction errors. Equation V.2 tests simultaneously for bias and first-order serial correlation in prediction errors. Since the estimation technique is nonlinear, we must rely on asymptotic statistics. As shown in Table VI, a likelihood-ratio test fails to reject the hypothesis of no bias and no serial correlation.

(iii) The actual spot rate must be the conditional expectation of the spot rate, given the forward rate. This means that in a regression of the form $s_t = \alpha + \beta F_{t-1}$ we should find $\alpha = 0$, $\beta = 1$. Equation V.3 tests this, and as shown in Table VI, fails to reject.

Table V
TESTS OF RATIONAL EXPECTATIONS

V.1	$(s_t - F_{t-1}) = 0.0101$ (.0104)			
	SSR = .3823	SEE = .0805	D-W = 1.8426	
V.2	$s_t - F_{t-1} = 0.0101$ (.0111)			
	SSR = .3807	SEE = .0803	$\hat{\rho} = .0655$	
V.3	$s_t = .2470 + .9471 F_{t-1}$ (.1384) (.0308)			
	SSR = .3624	SEE = .0790	$\hat{\rho} = .0856$	$R^2 = .9513$
V.4	$s_t = .0872 + .9237 F_{t-1} + .0710 M_{t-2}$ (.3812) (.0626) (.1604)			
	SSR = .3612	SEE = .0796	$\hat{\rho} = .0724$	$R^2 = .9515$
V.5	$s_t = .2487 + .9612 F_{t-1} - .0146 s_{t-2}$ (.1420) (.1076) (.1102)			
	SSR = .3623	SEE = .0797	$\hat{\rho} = .0748$	$R^2 = .9513$

Notes: The variables have the following definitions:

s_t = log of the spot exchange rate, francs per pound, for the last week in month t

F_t = log of the rate of exchange on 30-day forward contracts signed in the last week in month t

M_t = log of note circulation in the last week of month t

All equations are estimated for the period January 1922 to December 1926. Equation V.1 is estimated by OLS; the rest by the Cochrane-Orcutt iterative technique. Data is from Einzig (1937).

Table VI
LIKELIHOOD RATIO TESTS

Equation	Unconstrained SSR	Constrained SSR	# of observations	chi- squared	95 percent level
V.2	.3807	.3884	60	1.22	5.99
V.3	.3624	"	"	4.31	7.81
V.4	.3612	"	"	4.52	9.49
V.5	.3623	"	"	4.33	9.49

Notes: These tests compare the estimates in Table V with the null hypothesis $s_t = F_{t-1} + u_t$ where u_t is "white noise." The test is constructed by noting

that under the null hypothesis, $\frac{SSR^* - SSR}{SSR} \times n$ is distributed asymptotically

as $\chi^2(K)$ where SSR^* is the sum of squared residuals when the null hypothesis is constrained to hold, SSR the sum of squared residuals in the unconstrained regression, n the number of observations, and K the number of parameters set free in the unconstrained regression. On this, see Theil (1971).

(iv) One should not be able to improve on the forward rate as a predictor by using information available to the market when forward contracts were signed. This is tested in V.4 and V.5, respectively, in the regression. Neither contributes significant additional explanatory power.

While it is never possible to prove that expectations are rational, it can be said that the forward market in francs for 1922-26 passes the obvious tests of rationality. But we have also seen that, although it is not entirely satisfactory, an extrapolative scheme appears to account reasonably well for expectations. Since the stability of the economy depends on which of these is correct, is there any way to settle the question?

There are two points that should be made. The first is that the extrapolative expectations mechanism looks less adequate when we look at very short-run behavior. Dulles (1929) showed that movements in daily rates were clearly associated with unanticipated political events, suggesting that investors were more sophisticated in their behavior than an extrapolative scheme would allow.¹

The second point to make is based on the theoretical analysis of Part I. We saw there that a "rational" depreciation can look like a case of extrapolative expectations, but that the reverse is not true. If the actual mechanism of expectations formation were extrapolative we would expect to find evidence of persistent errors of prediction. What we have just shown is that there is no evidence for such persistent errors.

¹ An empirical study of foreign exchange markets by Black (1973) demonstrates the importance of political events by an ingenious dummy-variable technique.

In the end, however, the best argument for believing in sophisticated behavior by investors is that it enables us to tell a coherent story about the monetary history of France in the 1920's; and to explain why expectations appeared destabilizing in France when they have appeared stabilizing in other cases. I will develop the story below; but first it will be necessary to take a closer look at the monetary mechanism.

D. The Monetary Mechanism

The role of monetary expansion in exchange depreciation remains highly disputed. It is not denied that large depreciations are invariably accompanied by increases in the money supply, but some authors, notably Nurkse (1944) and Aliber (1962) have argued that the money supply is in fact endogenous, playing a passive rather than active role in the prices of depreciation. This fits in well with the model of extrapolative expectations developed in Part I, where an accommodating monetary policy can be a factor producing instability. In fact, there is considerable justification for a view that regards the money supply as an endogenous variable in the short run in post-World War I France.

Let us begin, however, by looking at the demand for money. We would expect the demand for money to depend on "the" interest rate. Unfortunately, no usable short-term interest rate data were available for France. I have dealt with this problem by exploiting the interest parity theorem to derive an implicit interest rate for France. In the absence of transaction costs and default risk, interest parity says that $r = r^* + \delta$, where r is the domestic interest rate, r^* the foreign interest rate, and δ the forward discount against domestic currency. Thus we can construct

an implicit interest rate for France by adding U.K. bank rate, converted to a monthly rate, to the 30-day forward discount on the franc. This variable appears as R in Table VII.

Table VII presents several estimates of the demand for money in France, 1922-26. The dependent variable in the equations is the log of "velocity," as measured by the ratio of the price level to the money supply. In VII.1 and VII.3 the price level is measured by retail prices; in VII.2 and VII.4 by wholesale prices. The independent variable in each case is the implicit interest rate defined above. I experimented with real output as an additional explanatory variable, but it did not have significant explanatory power.

Since, as we will see in a moment, the money supply and the interest rate must be regarded as jointly determined, it was necessary to use an instrumental variable technique in estimating these equations. I made use of a technique originally proposed by Wald and described in Theil (1971): a dummy variable was constructed, which equalled one in periods when the forward discount exceeded its median value, and zero elsewhere. Combining this with French bank rate to form instruments, we get the reported results. These indicate a well-behaved demand for money, although one with a good deal of "noise." The standard errors of the equations can be interpreted as typical percentage errors, and indicate that velocity was not very stable. But the interest rate had the expected sign, and a plausible magnitude: at a six percent annual rate of interest, a β of 20 would correspond to an interest elasticity of 0.1. Serial correlation, which can often be regarded as a test for misspecification, is substantial, but not exceptional given that we are dealing with monthly data.

Table VII
MONEY DEMAND EQUATIONS

<u>Equation</u>	<u>Measure of Prices</u>	<u>α</u>	<u>β</u>	<u>SEE</u>	<u>R^2</u>	<u>D - W</u>	<u>$\hat{\rho}$</u>
VII.1	RPI	-.066 (.020)	16.647 (2.491)	.081	.1274	0.825	--
VII.2	WPI	.078 (.031)	24.438 (3.855)	.125	.2476	0.645	--
VII.3	RPI	-.050 (.041)	14.853 (4.930)	.061	.5131	--	0.624
VII.4	WPI	.150 (.073)	16.147 (8.279)	.065	.7917	--	0.788

Notes: These equations are estimated on monthly data from December 1921 to December 1926. All estimates are of the equation $p - m = \alpha + \beta R$, where p is the log of the price level, m the log of note circulation, and R the implicit interest rate described in the text. The price level is measured by retail prices in equations labeled "RPI," by wholesale in equations labeled "WPI."

All equations were estimated by two-stage least squares; to form instruments, French bank rate and the Wald variable described in the text were used. In VII.3 and VII.4, 2SLS was combined with Cochrane-Orcutt; the estimated serial correlation is reported as $\hat{\rho}$.

Data on prices and note circulation are from International Abstract of Economic Statistics, 1919-1930; data on interest rates and forward rates from Einzig (1937).

These results support the contention that there was a well-behaved demand for money in interwar France. But what about lags in the adjustment of prices to nominal demand? Table VIII presents some tests for such lags. In an expression relating the price level to the supply of money, the interest rate, and the price level lagged, a positive coefficient on the last variable would be evidence for slow price adjustment. The results are somewhat similar in their implications to the tests for lags in section B above. Least squares estimates (Equations VIII.1 and VIII.2), while not turning up any evidence of a lag of wholesale prices behind money, do support the notion of a lag in retail prices. But this result, which confirms casual observation, may be the result of a statistical illusion; for when an instrumental variable approach is applied, there is no longer a clear case for the existence of a lag. It is at least an open possibility, then, that over the 1922-26 period the effect of monetary disturbances on prices was more or less immediate.

More problematical is the question of money supply. If by "money" we mean note circulation, this is a variable commonly regarded as a policy instrument. There is no reason to expect there to be a well-defined supply function of notes at all. Nonetheless, a comparison of note circulation with the implicit interest rate, R , shown in Figure II, conveys an irresistible impression of endogeneity. In the two sudden speculative attacks of 1923-24 and 1926, the increase in the implicit interest rate was accompanied by an increase in note circulation. This may in part have reflected changes in banks' borrowing via the discount window. But it is also reflecting the financial position of the government.

Table VIII
TESTS FOR LAGS OF PRICES BEHIND MONEY

<u>Equation</u>	<u>Dependent Variable</u>	<u>a</u>	<u>b</u>	<u>c</u>	<u>d</u>	<u>SEE</u>	<u>R²</u>	<u>$\hat{\rho}$</u>
VIII.1	WPI	0.223 (.065)	1.046 (.302)	2.976 (1.221)	0.095 (.146)	.037	.981	0.890
VIII.2	RPI	-0.002 (.074)	0.358 (.104)	1.166 (.705)	0.752 (.070)	.020	.992	0.464
VIII.3	WDI	0.305 (.116)	1.891 (.700)	9.544 (9.216)	-0.497 (.390)	.048	.968	0.904
VIII.4	RPI	-0.004 (.038)	1.240 (.558)	-3.165 (5.542)	0.270 (.308)	.030	.982	0.808

Notes: These are estimates of the equation $p = a + b \cdot m + c \cdot R + d \cdot p_{-1}$

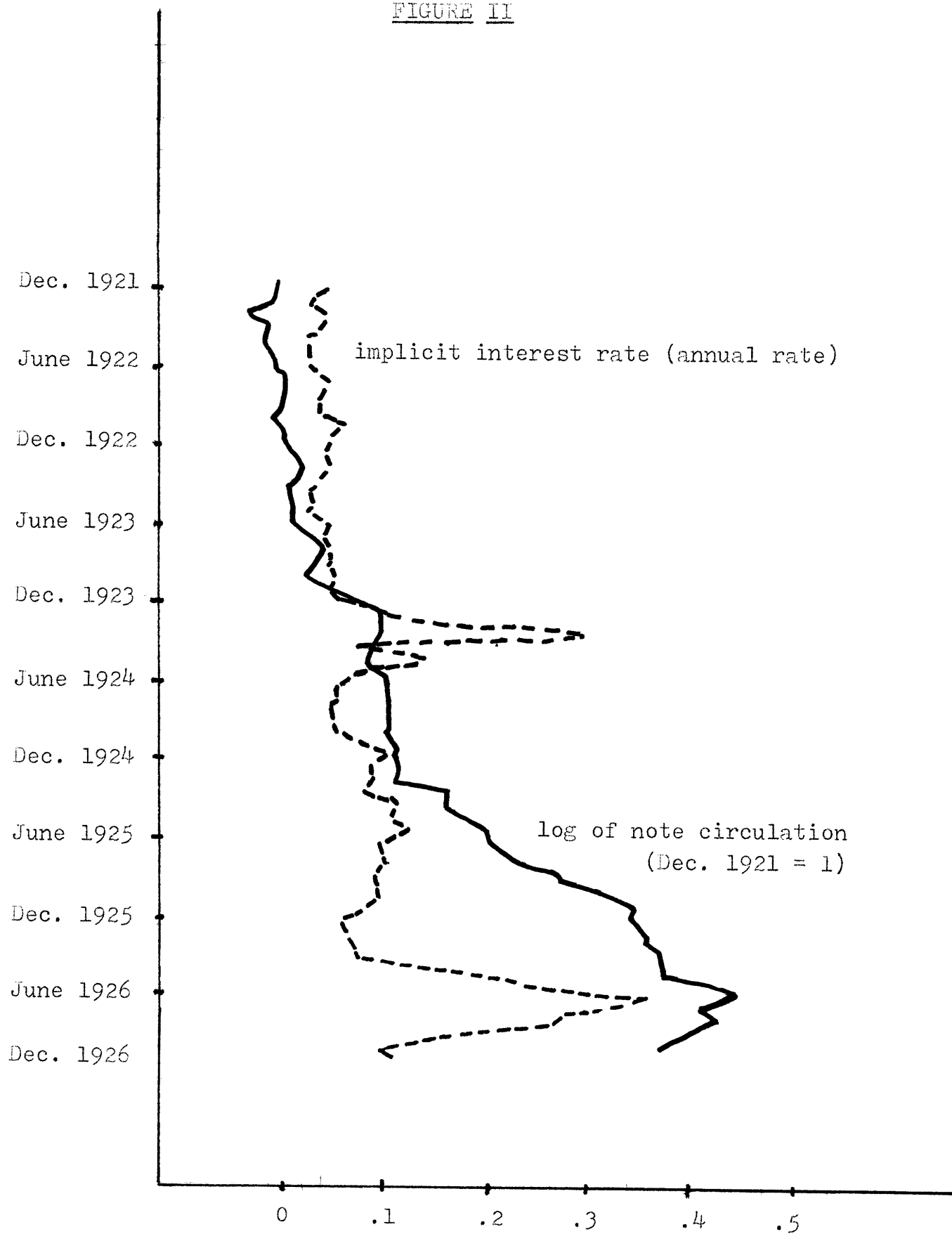
where p = log of price index

m = log of note circulation

R = implicit interest rate

The price index used is that of retail prices where the table indicates RPI, wholesale elsewhere. For sources of data, see Table VII. All estimates were monthly February 1922 to December 1926.

Equations VIII.1 and VIII.2 were estimated by Chchrane-Orcutt; VIII.3 and VIII.4 by a combination of instrumental variables and Cochrane-Orcutt, with the instrumental variables: time trend, bank rate, forward discount dummy, and lagged prices.

FIGURE II

For government finance, as a number of authors¹ have emphasized, was a major factor making France's monetary system "elastic." France emerged from World War I with a large public debt, much of it (about a third) in short-term securities. The existence of this debt, combined with the unwillingness of the government to vary the interest paid on securities, led to a situation in which speculative attacks on the franc induced monetary expansion. Whenever investors became less willing to hold franc-denominated securities -- i.e., the implicit interest rate rose -- the government was unable to roll over debt as it matured without offering higher interest rates. Instead of doing this, the government habitually acquired the necessary cash by borrowing from the central bank. In effect, increases in interest rates caused the government to monetize a part of its debt.

This process naturally had a negative effect on the real or apparent stability of the economy. If expectations were formed extrapolatively, the accommodating monetary policy of the government could have destabilized an otherwise stable economy. This possibility arose in the theoretical analysis of Part I of the paper, and played a key role in the analyses of Aliber and Tsiang. In the Appendix to this part of the paper, the question is examined empirically.

If expectations are assumed, instead, to have been rational, it is nonetheless plausible that an interest-elastic money supply in the short

¹ The role of the government budget in the money supply process during this period has been emphasized by Dulles (1929). Tsiang (1959) provided an analysis of the process of money supply, which was further extended by Aliber (1962).

run would make the economy seem less stable, because it would make the current exchange rate more sensitive to changes in expectations about future monetary policy. Following Mussa (1976), we can derive from the simple monetary model of Part I under rational expectations an expression for the current exchange rate of the form

$$s_t = K + \frac{1}{1 + (\lambda + \mu)} \sum_{j=0}^{\infty} \left(\frac{\lambda + \mu}{1 + \lambda + \mu} \right)^j E_t \bar{m}_{t+j}$$

where K is a constant, λ and μ are interest semi-elasticities of supply and demand for money, respectively, and \bar{m}_{t+j} is the expectation at time t of the shift parameter in money supply at time $t+j$. The further in the future is a change in \bar{m} , the less it matters; but the rate at which the importance of future events falls off is less, the more accommodating is monetary policy.

Government finance, then, is the key to understanding changes in the money supply in the short run. The budget also played a crucial role in determining the long-run rate of monetary expansion. Like most European countries, France was in financial difficulty in the years following the First World War. Since France won the war, its problems were not as severe as those of some countries; little difficulty was experienced in raising enough revenue to meet ordinary expenses. But France had paid for the war almost entirely by borrowing, and the debt service accounted for over 40 percent of expenditures in the middle 1920's.¹

¹ This figure is taken from Dulles (1929). Budget figures for France in this period are not trustworthy, since government finance consisted of dozens of independent budgets; but the order of magnitude is surely right.

In this situation, money creation offered an attractive alternative to government belt-tightening. By borrowing from the Bank of France, the government not only directly augmented its current revenue, it indirectly reduced future expenditures in real terms. This latter effect was first noted by Keynes (1924), who pointed out that increases in the money supply, by inducing inflation, reduced the real value of long-term debt. Keynes used this as an argument against returning the franc to its pre-war parity; but the argument holds equally as a reason why further inflation would have seemed attractive to the government.

Some authors have questioned the validity of Keynes' argument. Aliber (1962), in particular, argued that the tax system was incompletely indexed, so that real revenues fell as a result of inflation. This led him to maintain that expectations of depreciation were self-fulfilling, because they led to greater budget deficits and therefore monetary expansion. The evidence is, however, against this argument. Table IX gives some comparisons of revenue and expenditure with retail prices. As Aliber argued, revenues barely kept up with retail prices, in spite of new taxes, which may be an indication of less than complete indexation of the tax system. But this was more than compensated for by the failure of expenditure to rise in proportion to prices. This is not surprising when one bears in mind that most of the expenditures of the French government went for debt service, pensions, and wages, all of which failed to keep pace with inflation. There can therefore be little doubt that Keynes was right in arguing that inflation had a beneficial effect on the budget.

Thus there was a real incentive for the French government to pursue a policy of inflation. How did the government respond? From 1922 to 1928

Table IX
PRICES AND THE BUDGET
(Billion Francs)

	Retail prices, June	Revenue	Real revenue	Expend- iture	Real expend- iture	Debt service	Real debt service
1922	307	24.2	24.2	48.9	48.9	14.1	14.1
1923	331	27.7	25.7	45.8	42.5	14.7	13.6
1924	370	31.1	25.8	40.2	33.4	15.6	12.9
1925	422	29.5	21.5	34.2	24.9	15.5	11.3
1926	544	45.1	25.5	44.9	25.3	15.9	9.0

Notes: Real revenue and real expenditure are revenue and expenditure in 1922 francs, using retail prices as deflator. All data is from Dulles (1930).

note circulation increased by two-thirds. The increase was not, however, achieved by a deliberate policy of money finance. It was primarily achieved in two ways. We have already seen one of them: the monetization of short-term debt in response to speculation against the franc. The other was money creation through the balance of payments. In 1926, when the franc began to recover from a speculative attack, the Bank of France intervened to hold the franc at four cents. At that rate there was an immediate capital inflow; further, the exchange rate was high enough to produce large current account surpluses for the remainder of the 1920's, which were not sterilized.

It would almost surely be wrong, however, to regard the inflation in France as accidental and independent of government policy. A more accurate description of what happened would be that the government avoided taking action until it was forced to; but that the actions it then took were in the direction of inflation.

E. An Interpretation of Events

What happened in France 1922-1926? Was it an unstable speculative run, or simply a matter of sophisticated forward-looking behavior by investors? We now have enough evidence to attempt to provide an answer.

In the discussion above I have analyzed a number of aspects of the French experience. Three results should be emphasized in particular:

(i) The evidence from the forward markets is consistent with the notion that expectations about future exchange rates were formed in a sophisticated, "rational" manner.

(ii) Because of the endogeneity of the money supply, the exchange rate was highly sensitive to changes in expectations.

(iii) The government was subject to budgetary difficulties which could be, and in the end largely were, solved by inflation.

These observations, together with the theoretical analysis, suggest a simple story about what happened in France. If we grant that there were forces pushing the government toward inflationary policies; and if we further suppose that speculators were aware of these forces; then the natural explanation of depreciation in France is that the market was reacting to anticipated monetary expansion. Political news would produce sudden changes in exchange rates whenever it led investors to change their opinions about the likely monetization of the debt.¹

This explanation is attractive because it is economical. Events in France can be seen as being all of one piece, deriving ultimately from the French decision to finance the First World War entirely by borrowing. And it provides a reason why the behavior of speculators in francs appears destabilizing when at the same time speculation in, say, Dutch guilders seemed stabilizing.

But if the explanation is correct, we must conclude that speculation did not play an autonomous role in making the French economy unstable.

¹ An instructive example is provided by the crisis of summer 1926. That crisis was set off by the appointment of a Finance Minister who was an avowed believer in the plafond unique: a doctrine which held, in modern terminology, that short-term debt and cash were equally liquid assets and that therefore monetizing part of the government's short-term obligations would not have an inflationary impact. The market disagreed, and the franc fell sharply. This account is drawn from Dulles (1929).

² For descriptions of monetary developments in other European countries during the same period, see Tsiang (1959) and Aliber (1962).

In fact, the economy was not unstable at all. Depreciation was caused by the government's budget problems, and in the end provided its own cure.

France in the 1920's has always been regarded as a key example of the undesirability of flexible exchange rates. I have shown that the alleged instability caused by speculation is highly questionable, and that on balance the evidence suggests a stable economy. The major lesson to be learned may be that casual observation is not always sufficient as a basis for judging how well a market is working.

APPENDIX TO PART II

THE STABILITY OF THE FRENCH ECONOMY

If expectations are formed in an ad hoc, extrapolative manner, there is a possibility of large-scale speculative runs which destabilize the economy. While the conclusion of this paper has been that expectations were in fact formed in a more sophisticated way, it is interesting to impose the hypothesis of extrapolative expectations and examine the stability of the system.

Let us suppose, then, that the French economy can be described for our purposes by three equations: a demand for money schedule, a supply for money schedule, and an expectations formation equation, with the following functional forms:

$$(B1) \quad p - m = \alpha_0 + \alpha_1(r^* + \delta)$$

$$(B2) \quad m = \beta_0 + \beta_1(r^* + \delta) + \beta_2 d + \beta_3 t$$

$$(B3) \quad \delta - \delta_{-1} = \gamma(s - s_{-1}) - \gamma\delta_{-1}$$

where

p = log of the wholesale price index

m = log of note circulation

r^* = foreign interest rate

d = central bank discount rate

t = time trend

δ = forward discount on the currency

s = log of the exchange rate

The system may be closed by the assumption of purchasing power parity, $s = p$.

If we disregard the case of unstable oscillations, stability of this system depends on whether $\gamma(\alpha_1 + \beta_1)$ is less than or greater than one (as shown in Part I).

Table X reports an estimate of the system (B1) - (B3) on French data 1922-1926. It was assumed that (B1) and (B2) were characterized by first-order serial correlation of the error terms, so the system was estimated by nonlinear three stage least squares. The estimates of (B1) and (B3) differ somewhat from the estimates reported in Tables II and VII, above, because of the use of a different instrument list and because the estimates here take account of cross-equation covariance.

Of the estimates, one should note in particular the money supply equation. Perhaps surprisingly, the coefficients on the interest rate and the rediscount rate come out with the right signs. The implausibly large coefficient on the rediscount rate suggests, however, that the rate is serving as a proxy for monetary policy in general. Thus the equation is presumably more or less misspecified.¹ But it nonetheless confirms the impression of endogeneity of the money supply.

Using the estimates in Table X, we can test for stability by computing the value of $\gamma(\alpha_1 + \beta_1)$. We can then compare this statistic with the value of $\gamma\alpha_1$, which is Cagan's (1956) test statistic -- the condition for stability

¹ The fact that it was not possible to come up with a plausible money supply equation is the reason the estimates of (B1) and (B3) used in the text are based on limited-information methods rather than full-information methods of the kind used here. For full-information methods allow a misspecification of one equation to "contaminate" estimates of others.

Table X
SYSTEMS ESTIMATES

$$(B1): \quad p - m = 0.198 + 13.790 (r^* + \delta) \\ \quad \quad \quad (.098) \quad (10.267)$$

$$\hat{\rho} = 0.899, \quad SEE = .039, \quad R^2 = .921$$

$$(B2): \quad m = 0.189 + 11.155 (r^* + \delta) \\ \quad \quad \quad (0.181) \quad (5.274)$$

$$- 77.362 d + 0.009 t \\ (45.708) \quad (0.002)$$

$$\hat{\rho} = 0.887, \quad SEE = .015, \quad R^2 = .990$$

$$(B3): \quad (\delta - \delta_{-1}) = 0.035 [(s - s_{-1}) - \delta_{-1}] \\ \quad \quad \quad (.006)$$

$$SEE = .0037, \quad R^2 = 0.2895, \quad D-W = 2.209$$

Notes: These equations were estimated simultaneously by three-stage least squares. The variables have the definitions given in the text. Data was monthly from January 1922 to December 1926. The instrumental variables were: the right hand side variable in (B3), the rediscount rate, time trend, the dummy variable for forward discount described in the text, lagged $p - m$, and lagged m .

Price and money supply data are from International Abstract of Economic Statistics, 1919-1930; exchange market data from Einzig (1937).

if the money supply is exogenous. We find the following: the point estimate of $\gamma\alpha_1$ is 0.485, with an asymptotic standard error of 0.371; the point estimate of $\gamma(\alpha_1 + \beta_1)$ is 0.878, with an asymptotic standard error of 0.428. In both cases the point estimate is within the stable range, while in neither case can we reject at the 95 percent level the hypothesis of instability. But the endogeneity of the money supply does push the structure of the economy closer to the border of instability.

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